Strengthening the research capacity and innovation potential of the Institute of Polymers at the Bulgarian Academy of Sciences for further intergration into the ERA

Reporting

Project Information

POLINNOVA

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Final Report Summary - POLINNOVA (Strengthening the research capacity and innovation potential of the Institute of Polymers at the Bulgarian Academy of Sciences for further intergration into the ERA)

Executive Summary:
The IP-BAS staff exchanged knowledge and expertise in the field of advanced polymer materials with 6 partnering organizations, leading European research centers, via transnational two-way secondment program which included 20 long-term secondments and 48 short-term visits that covered in total 39 months. This resulted into 6 new research topics, 19 joint papers and 25 conference presentations and joint proposal initiatives. Ten experienced researchers and 2 experienced technicians were recruited at IP-BAS increasing the RTD capability and competitiveness of the staff. They co-authored 28 research papers, 1 patent application, 5 proposals and participated in 18 scientific forums.The recruitment of 4 Bulgarians contributed to obtain a 'brain gain' effect and encourage young specialists to consider career at home. Importantly, two of them have been employed at permanent positions at the Institute.
The research infrastructure at IP-BAS was upgraded with a combined GPC/MALLS line, TGA-GC-MS hyphenated instruments, DMT analyser and static/dynamic and electrophoretic light scattering equipment. IP-BAS staff received adequate training on operation of the new equipment. It has become an advanced platform for precise polymer characterization and frontier investigations.
The knowledge of IP-BAS staff on IPR issues as key factor in the innovation performance have been increased through participation in training events, workshops, twinning activities, etc. Two experts with complementary skills in IPR and innovation were recruited on a part time schedule at the IP manager position. A strategic plan for innovation capacity building was elaborated including Research priority areas; Rules for protection and management of the Intellectual Property and Strategy for increasing the innovation potential of IP-BAS. The research results with innovation potential were communicated at international and national forums, exhibitions, meetings with industrial representatives or via public media. The innovation activities have marked a notable increase – 3 patents and utility model applications were filed.
Publication activity and participation of IP-BAS researchers at scientific forums increased considerably. Dissemination included also organization of annual poster sessions "Young scientists in the world of polymers" and an international conference "Challenges in Science and Technology of Polymer Materials". The conference was attended by scientists from 18 countries from Europe, USA and Asia. The general public and business community have been addressed by issue and distribution of the annual IP-BAS booklets, brochures, organization of Open days, media interviews, meetings with companies, etc.
The overall quality of the research and innovation potential of IP-BAS was evaluated by a group of external independent experts The evaluation took into account several indicators: human resources, infrastructure and equipment, research results, national and international collaborations, connections and partnership with regional stakeholders, organizational and management structure. The experts' team delivered an Evaluation Report including updated SWOT analysis and forward-looking section "Recommendations and Strategic Guidance". The evaluators' findings, conclusions and recommendations were communicated and discussed at a workshop.
The project management was conducted using efficient and transparent procedures for activities organization and dealing with the finance. All staff contributed to achieving the project objectives. The progress of the project has been revealed to the public by its duly updated website. The POLINNOVA Advisory Board supported the decision making process in key issues of the project implementation. The project results and its impact for enhancing the quality of the research output of the institute and strengthening the research capacity and innovation potential were communicated at the POLINNOVA closing event held on 25.03.2016.

Project Context and Objectives:
Innovations and technology progress are the main drivers of the economy in overcoming the societal challenges. Chemistry and polymer science as its integral part, has been always offering solutions to meet the new occurring needs. Many of these solutions are related to novel functional materials. Polymers being an extremely large class of materials are used for energy storage materials, in electronics, communication and transportation, in medicine, pharmacy, agriculture, food industry, etc. Nanotechnology in combination with polymer materials engineering is expected to give new impetus for an innovative materials design and expanded applications and thus to contribute to economic growth and wellbeing.
The Institute of Polymers, Bulgarian Academy of Sciences (IP-BAS) is an autonomous research unit and has been the leading center of polymer research in Bulgaria fostering a 55-year tradition of fundamental and applied studies on polymers and polymer materials. Being coherent with the vanguard trends in polymer science and technology its research policy has always been oriented to meet the requirements set by society needs. The Institute has developed a world-class level of expertise in polymer synthesis as recognized by independent international evaluators. Based on the strong fundamental ground, the scientific activities of IP-BAS are strongly relevant to the strategic fields of research in Europe – new materials and nanotechnologies oriented to healthcare and energy/ecological purposes. The IP-BAS achievements and international reputation are results of the efforts of the highly qualified and dedicated staff of the Institute. Its researchers are among the leading scientist in Bulgaria and with world reputation in the field.
IP-BAS has been putting much effort to keep itself well integrated in the national, regional, and European research communities. The research policy of the Institute is also coherent with the key objectives for sustainable development of Bulgaria as an EU member state formulated in a number policy documents: The achievements of the Institute as well as its development objectives clearly match the goals of the work program and the call FP7-REGPOT-2012-2013-1.
The main goal of the POLINNOVA project is: to strengthen IP-BAS research and innovation potential in the field of advanced polymer materials and to build its capacity of a regional leader participating successfully in activities at European Union level.
The key concept of the project is to implement the Action Plan derived from a complete SWOT analysis. The Action Plan consists of coherent measures, initiatives, and activities that are designed to achieve the main goal of the project. The Action Plan is being realized by mobilizing the entire IP-BAS human and material resources in close cooperation and networking with the eight twinning organizations. The specific objectives of the project to be achieved by implementation of the Action Plan are:
- to strengthen the research capacity and to develop the innovation potential of IP-BAS through building strategic partnerships with leading European research organizations - exchange of know-how and experience with them;
- to increase the human potential by attracting, recruiting and retaining the experienced researchers and technicians;
- to upgrade and extend the S&T equipment to ensure a scientific infrastructure for world class research and innovation;
- to unlock the Institute’s innovation potential through a Plan for innovation capacity building and measures for increasing the Intellectual Property awareness of the staff;
- to stimulate the partnership with targeted industries, including SMEs, and comprehensive dialogue with policy makers to identifying the specific societal demands;
- to promote IP-BAS participation in research and innovation activities at EU level;

- to increase the visibility of IP-BAS excellence through dissemination and networking at national, regional and European level.

The specific objectives also involve evaluation of IP-BAS overall research performance and innovation potential by independent experts. The ex-post evaluation aims at assessing the progress made upon project completion and to assist the Institute in deriving an updated SWOT analysis and to provide strategic guidance and recommendations for the development strategy of IP-BAS.

The activities undertaken within the Action Plan include: (i) transnational twoway secondments between IP-BAS and six European partnering research organizations, (ii) recruitment of experienced scientists and technicians, as well as of Intellectual Property and innovation manager(s), (iii) upgrading of the available and acquisition of new equipment in the context of the research objectives of the Institute, (iv) training in Intellectual Property rights and innovation capacity development, (v) organization of scientific forums and other promotional activities and (vi) evaluation of IP-BAS overall research performance and innovation potential.

The scientists at IP-BAS have ever been motivated to boost the Institute's research capacity and innovation performance and to benchmark with the best Europe centers in polymer research and innovations. The activities undertaken within the project have been accomplished in partnership with six highly experienced and outstanding research organizations listed below:

Partnering Organizations:

- Department of Organic Chemistry, Ghent University (Belgium);
- Center of Innovation and Research in Materials and Polymers, University of Mons (Belgium);
- The UCL School of Pharmacy, University of London (UK);
- Centre of Polymer and Carbon Materials, Polish Academy of Sciences (Poland);
- University of Castilla-La Mancha, Department of Chemical Engineering (Spain);
- National Hellenic Research Foundation, Theoretical and Physical Chemistry Institute (Greece);
- Bulgarian Association Polymers (Bulgaria)

The Branch Association Polymers (former Bulgarian Association Polymers) has been identified by IP-BAS as a strategic partner, which represents 37 Bulgarian companies processing and marketing polymers and plastics. The Association has been involved in dissemination, promotional and other activities and mediated the interactions of the Institute with targeted industries.

Upgrading the RTD capacity within the project has initiated IP-BAS excels in the quality of research it carries out. The enhanced innovation potential leads to more effective use of research results relating to innovative advanced polymer materials and aims to contribute to the sustainability of the regional economic and social development. The anticipated impact includes also a more successful participation in the national, regional and European funding programmes as well as further integration of IP-BAS into the ERA.

Project Results:

The project results were obtained from the accomplishment of different activities distributed in seven work packages (WP). Six of the WPs included supporting activities as follows: WP1 and WP2 were set to the reinforcement of the human potential through (i) trans-national two-way secondments of the research staff of IP-BAS and the partnering organizations and (ii) recruitment of experienced researchers and technical

staff, WP3 was dedicated to the improvement of IP-BAS research infrastructure through upgrading and acquisition of research equipment, WP4 activities aimed at unlocking the innovation potential of the Institute, WP5 includes dissemination and communication activities and WP6 was focused on evaluation of IP-BAS research potential and innovation capacities by independent experts nominated by EC. The activities have been horizontally integrated through networking with the partnering organizations and synergistically enhanced by mutual complementarities. In addition WP7 was defined for the management of the project to provide coordination of the activities and precise implementation of the work plan following the timeline of the project.

WP1. Twinning with leading European research centers via exchange of knowledge, experience and know-how.

The objective of this work package was to enhance the qualification of IP-BAS researchers to perform frontline research in advanced polymer materials and to ensure further integration into ERA. To realize these objectives, transnational two-way secondments between IP-BAS and the following 6 experienced and outstanding research partnering organizations were implemented:
• Polymer Chemistry Research Group, Department of Organic Chemistry, Ghent University Belgium (PCRG): secondments for design, controlled synthesis and characterization of novel well-defined polyelectrolyte homo- and copolymers of various architectures (linear and star-like).
• The UCL School of Pharmacy, University of London UK (UCLSP): secondments for exchange of knowledge in the field of polymer-based drug delivery systems.
• Centre of Polymer and Carbon Materials, Polish Academy of Sciences Poland (CPCM): secondments for preparation and characterization of a series of polymer mesoglobules and hollow nanospheres in aqueous media using various thermally sensitive synthetic polymers and peptide/polymer conjugates.
• University of Castilla-La Mancha, Department of Chemical Engineering Spain (ITQUIMA): secondments for development of a new technique for the preparation of biodegradable nanocomposites with antimicrobial properties and potential application in active packaging; fabrication and testing of membrane electrode assemblies (MEA)s with cross-linked polymer membranes obtained at IP-BAS.
• National Hellenic Research Foundation, Theoretical and Physical Chemistry Institute Greece (TPCI): secondments for investigation of complex formation between charged (co)polymers or copolymer micelles and biomacromolecules (DNA, BSA, insulin or lysozyme).
• The University of Mons, Center of Innovation and Research in Materials & Polymers (CIRMAP): secondments for design, fabrication and evaluation of physico-mechanical properties of novel electrospun micro- and nanofibrous polymer materials; synthesis and characterization of novel multifunctional oligomers and polymers with potential application in organic solar cells.

The results within WP1 have been obtained through the implementation of the following tasks:
Task 1.1. Secondments of research staff from IP-BAS to twinning organizations.
A detailed schedule was prepared after consultations with the partnering organizations and the research groups from IP-BAS. The project's Management Group approved secondment applications. As a result, during the project implementation 20 long-term secondments of researchers from IP-BAS to the partnering organizations were realized for a total period of 24.3 months. Additionally, 29 short-term visits of experienced researchers to the European partners for a total period of 10.2 months took place.
During the long-term visits of researchers from IP-BAS to the partnering organizations an exchange of

experience and knowledge in advanced methods for polymer and polymer materials synthesis and characterization was achieved. The three most visited from IP-BAS research staff partnering organizations were ITQUIMA (5 visits for total duration of 6.6 months), CIRMAP (5 visits for total duration of 6.2 months) and CPCM (6 visits for total duration of 5.9 months). As a result from the realized long term visits the seconded researchers of IP-BAS enhanced their skills in the fields of advanced copolymer structures for biomedical applications; functional materials based on stimuli-sensitive and biodegradable polymers; and copolymers or polymer materials with environmentally relevant properties.
The short-term visits of the experienced research staff from IP-BAS to the European partnering research organizations resulted in exchange of knowledge via presented lectures, participation in discussions concerning the ongoing and future joint investigations with the respective partners. Key experiments during some the visits were also performed. Additionally, the recruited within WP2 of the project experienced researchers being members of IP-BAS staff were also able to visit the partnering organizations (9 visits for total duration of 4.1 months).

Task 1.2. Secondments of experienced research staff from twinning organizations to IP-BAS.
In line with the work package objectives and planned activities 19 short-term visits of experienced researchers from the project's partnering organizations for a total period of 4.6 months were realized at IP-BAS.
The overall implementation of WP1 tasks clearly contributed to the accomplishment of project's goal which was to strengthen the IP-BAS research and innovation potential in the field of advanced polymer materials. The activities performed within WP1 have been coherent with the research strategy of IP-BAS. Moreover, they have contributed to the development of applied research which is a base that would lead to results appropriate for commercialization. The gained and widened research expertise is important for successful participation of IP-BAS in relevant HORIZON2020 programme calls.
As a result of WP1 tasks implementation the research staff of IP-BAS acquired or improved their skills to operate dynamic and static light scattering instruments, multi-detector size-exclusion chromatograph and atomic force microscope. These instruments are now available at IP-BAS as result of the efforts to enhance the research infrastructure within the POLINNOVA project and a project funded by the European Regional Fund.
The efficiency of the research exchange within the secondments towards the project's strategic objectives accomplishment were quantified with the following measurable indicators:
* Establishment of 6 new research topics with partnering organizations:
- silicone materials with adhesive properties;
- interactions between synthetic polymers and proteins;
- novel biodegradable materials obtained under supercritical carbon dioxide conditions;
- novel oligomers and polymers with potential application in organic solar cells;
- polymer-based scintillators for neutron detection;
- organic phosphorus-containing ionic liquids for carbon dioxide capture
* 25 presentations of joint research at conferences and other forums
* 20 published joint scientific papers with an average impact factor of 4.108
* A submitted joint research proposal in the frames of HORIZON 2020 programme

WP2. Reinforcement of Human Resources
The IP-BAS human resources were enhanced by recruitment of 10 experienced researchers having high

qualification in different fields of polymer science coherent with the strategic research and innovation objectives of IP-BAS. Two experienced technicians were recruited as well, which ensured proper and high quality service of the available and newly acquired instruments.

Experienced researchers:
Dr. Georgi Grancharov - Employment duration: March 18, 2013 – still employed
Field of expertise: Organic photovoltaic and light-emiting devices; Novel regioregular poly(3-hexyl-tiophene) macroinitiators

Dr. Joanna Rydz-Pawlak - Employment duration: April 25, 2013 – September 30, 2015
Field of expertise: Solvent induced polymerization of lactones in presence of zwitterion compounds

Dr. Sonia Zulfiqar - Employment duration: June 4, 2013 - September 30, 2013
Field of expertise: Novel materials for CO2 capture and water treatment; Organic-inorganic nanocomposite materials; Nanomaterials for solar cell applications; Incorporation of metal nanoparticles into polymer films

Dr. Indraneel Sen - Employment duration: June 4, 2013 – September 30, 2015
Field of expertise: Polymer thin films for neutron scintillator detectors; Polymer nanocomposites containing metal and metal alloy nanoparticles for devices and sensors; Physical and opto-electronic properties of stereo- specific polymers

Dr. Sharif Shaheen - Employment duration: September 5, 2013 – September 30, 2015
Field of expertise: Liposomal delivery of drugs and DNA

Dr. Daniel Gromadzki - Employment duration: January 10, 2014 – September 30, 2015
Field of expertise: Polymer synthesis and modification, controlled radical polymerization, self-assembly, block copolymers, ionomers, bio-based polymers, smart polymers for biomedicine

Dr. Georgi Lalev - Employment duration: January 10, 2014 – June 15, 2015 (part-time)
Field of expertise: HR-TEM, cryo-TEM, HR-TEM tomography, AFM, confocal and fluorescence microscopy, nanoimprint lithography, photolithography,UV–nano-imprint lithography, injection molding, electroforming

Dr. Mikhail Filatov – Employment duration: March 13, 2014 – September 15, 2015
Field of expertise: Multistep organic synthesis, synthesis of polymeric nanoparticles, characterization techniques, optical spectroscopy, electrochemistry

Dr. Piotr Rychter – Employment duration: September 3, 2014 –September 30, 2015
Field of expertise: Ecotoxicological impact of polymers and their degradation products onto environment, controlled-release technology for agrochemicals, utilization of wastes containing biodegradable polymer for their further application

Dr. Maria Karayianni – Employment duration: January 13, 2015 – September 30, 2015

Field of expertise: Self-assembly of macromolecules in solution, block polyelectrolyte micelles and nanoparticles, structural studies of proteins, electrostatically assembled macromolecular complexes

Experienced Technicians:
Dr. Pencho Tuleshkov - Employment duration: December 2, 2013 – still employed
Field of expertise: Working with research equipment; Taking responsibilities for providing consumables for the equipment; Maintaining the equipment; Performing analyses and interpretation of results; Working with specialized software; Working with other research equipment that is available at the IP-BAS

Alexandar Stoyanov - Employment duration: January 2, 2014 – November 4, 2015
Working with research equipment; Taking responsibilities for providing consumables for the equipment; Maintaining the equipment; Performing analyses and interpretation of results; Field of expertise: Working with specialized software; Working with other research equipment that is available at the IP-BAS

The recruited highly experienced researchers contributed very much to enhancing RTD and S&D potential and achieving the strategic research and innovation objectives of IP-BAS. They shared the knowledge and expertise the staff and PhD students at the institute, participated actively in innovation, networking and dissemination activities. The recruited researchers produced 28 research papers, 5 proposals, 1 patent, and participated in 18 scientific forums. The increased human potential, broadened research scopes and competence boosted the research quality of IP-BAS at a higher level.
The activities of the 2 experienced technicians, recruited within the project, were directly associated to the newly acquired equipment. They were actively involved in the installation of the instruments, staff training, developing analytical protocols, sample analysis, interaction with companies, etc.
The recruitment of four Bulgarians – two of the experienced researchers and the two technicians – contributed to obtain a 'brain gain' effect and encourage young specialists to consider career at home. Importantly, two of them – Dr. Georgi Grancharov and Dr. Pencho Tuleshkov – were employed at permanent positions at the Institute upon the completion of the project.

WP3 Enhancement of the research infrastructure
The objectives of WP3 were focused on the enhancement of the research infrastructure and S&T capacities for innovative research in the polymer opportunity areas by upgrading the existing technical equipment and acquisition of new modules and instruments. The modernization of the research infrastructure was of primary importance for achieving the desired high scientific level in development of advanced polymer materials, including nano materials. A total of 519000 euro (24% of the project budget) was allocated for purchasing new instrumentation. In addition the amount of 20000 Euros were planned in the project budget to cover the cost of needed consumables for the installation trials and training on the instruments exploitation (GPC columns, standards, reagents, filters, cuvettes, etc.), as well as other items needed for the installation and proper functioning of the new apparatuses (e.g. laminar flow cabinet/hood or accessories). The purchase of all instruments, including consumables, was done through open procurement procedures following strictly the national legislation, i.e. the Public Procurement Act.
The results from the implementation of the WP3 tasks are described below.

Task 1. Upgrading the equipment for precise determination of molecular weight characteristics of polymers and polymer materials by acquiring a new GPC line equipped with a set of modern modules – RI,

UV and LS detectors.
The contract with the provider of a combined GPC/MALLS system was signed in July 2013 for a price within the allocated resources. The instrumentation consists of the following modules:
- GPC station Alliance e2695 (Waters Corp.);
- UV-Vis detector 2998 PDA (Waters Corp.);
- MALLS detector DAWN HELEOS II (Wyatt Tech. Corp.) with built-in QELS and COMET ultrasonic cleaning system;
- Optilab r-EX detector (Wyatt Tech. Corp.).
The system was equipped also with a high temperature line and batch conversion kit as well as with GPC-option of Empower (Waters) software for operational control, data collection and processing. When the exploitation of the combined instrumentation started it was found that to expand its capabilities an e-Sat/In module to translate analog signals from Optilab r-EX refractive index detector to digital signals for data collection and calculation with Empower software was needed, which was purchased and installed.
The necessary consumables for the trials and training on the instruments exploitation, such as chromatographic (GPC) columns (a set of Plgel columns), polymeric standards (a set of polystyrene standards), solvents HPLC grade, membrane filters, syringe filter holders and filters etc. were also purchased in accordance with the foreseen resources.
It should be noted that the purchased equipment even excels in performance and capabilities initially set as a target in the project. The acquired GPC/MALLS line is a combination of apparatuses produced by two leading manufacturers. It also comprises “batch” conversion kit and specially designed high temperature line provided additionally. Moreover, the e-Sat/In module allows simultaneous use of the data from the RI detector with both software products enhancing the instrument efficiency.
The GPC equipment has given IP-BAS great opportunities for analysis and characterization of specific polymer samples thus solving complex analytical and structural tasks. The enhanced capacities for complex materials analysis – simultaneous determination of main polymer characteristics such as molecular mass and molecular mass distribution, as well as parameters of polymer based aggregates/particles formed in solution – meet the research priorities of the institute and broaden its potential for innovative research.

Task 2. Upgrading the available equipment for physical and thermo-mechanical characterization by acquisition of new instruments for investigating the behaviour of polymers and polymer materials in solution, solid state and melt.
2.1. Purchasing a new complex equipment for investigation of polymers, polymer solutions and colloidal systems using static/dynamic and electrophoretic light scattering
The combined equipment for investigation of polymer solutions and colloidal systems using static/dynamic and electrophoretic light scattering was delivered within the approved period extension of WP3 activities. The reason for that was the failure of the offers to cover the technical specification in the first procurement procedure which required reopening of the procedure.
The contract with the provider was signed in the beginning of November 2015 and at the end of November 2015 the instrumentation was delivered and installation completed, as well as staff training. The equipment consists of the following modules:
- BI-200SM research goniometer (Brookhaven Instruments Corp.)
- NanoBrook 90Plus Pals zeta sizer (Brookhaven Instruments Corp.)
- DNDC analyzer (Orange Analytics Company)

The equipment can operate in following modes:
- the goniometer – dynamic or static light scattering.
- the zeta sizer – electrophoretic mobility or size measurements.
- the DNDC module – refractive index increment measurement.
The consumables for the trials and training on the instrument exploitation were included and delivered within the contract.
The behaviour of (co)polymer(s) in solution is another important investigation matter. The purchase of a composite instrumentation combining the capabilities of both particle size and zeta potential analyzer is a great advantage. It allows simultaneous determination of the size and shape of complex macromolecular structures, nano(micro)particles, micelles or aggregates in their colloid solutions as well as the potential at the interfacial boundary. Instrumentation composed of two separate apparatuses (a DLS/SLS goniometer and a Zeta determination module) provides stronger ground for advanced research in the field of polymer nano-colloids. Applying the DLS/SLS goniometer the research staff can develop experimental and analytical protocols based on a broad range of variables taking into account the particular system studied. This equipment is also of great importance for studying the effect of different parameters (polymer concentration, pH, ionic strength, temperature) on the stability of aqueous dispersions. The stability of the colloid systems is crucial for their applications in pharmacy and medicine.

2.2. Upgrading the existing TGA instrument via coupling with mass spectrometer for determining material structure and its decomposition, oxidation or loss of solvent under heating
In general, the link between the thermogravimetric analyzer (TGA) module and the mass spectrometer (MS) detector is a critical issue for efficient and feasible operation. A detailed inquiry was done of the possible schemes to connect the MS to the existing at IP-BAS TGA apparatus (Perkin Elmer TGA 4000) which provides degradation of the sample under atmospheric pressure with constant argon flow. The studied practices showed that the direct hyphenation, i.e. without a separation column, was not efficient in view of sensitivity and product identification. Therefore, the technical specification prepared for the procurement procedure included a Gas Chromatograph (GC) connection for coupling the MS Detector (MSD) to the available TGA apparatus.
The contract for the supply of the equipment was signed on 13.07.2014 for a price within the allocated resources. On 28.11.2014 the instrumentation was delivered and on 19.12.2014 the hardware as well as software installation was completed.
The instrumentation consists of the following modules:
- Gas Chromatograph Clarus 600 (PerkinElmer);
- Single quadrupole mass-selective detector Clarus SQ8S (PerkinElmer);
- Heated transfer line (RedShift) and control module (RedShift);
The equipment is supplied with PYRIS software for the thermogravimetric analyzer, TurboMass software for the mass-selective detector and NIST spectra library.
The equipment can operate in following modes:
The TGA module – measures mass change in inert gas flow (argon) with controlled temperature elevation.
The gas chromatograph/mass-selective detector line – manual injection of liquid samples. Separation of gas phase components after evaporation of the liquid sample under controlled temperature programming and helium flow. The MS detector measures the spectra of the separated substances. Qualitative identification of main components and impurities is achieved via NIST spectra library.
The triple TGA/GC/MSD combination – the gas flow from thermal decomposition in the TGA module is

injected via gas-sampling valve in the GC line, separated and then analyzed by the MS detector. Qualitative identification of main components and impurities is achieved via NIST spectra library as well.
TGA/MSD – specific ion monitoring from thermal decomposition in the TGA module via Argon flow without gas phase separation. Quantitative identification of the degradation products is achieved.
Acquisition of the necessary consumables for the trials and training on the instruments exploitation, such as disposable aluminum pans, high purity gasses, etc. were purchased in accordance with the foreseen for those purpose resources.
It should be noted that the designed and acquired system equipped with a gas-chromatograph connection provides more opportunities for separation and analysis of the released volatile compounds in the TGA module. Practically, the GC/MS line can be used also independently. In addition, the installed library of mass spectra facilitates the reliable product identification.

2.3. Upgrading the available equipment for thermal and mechanical characterization with dynamic mechanical (thermal) analyzer (DM(T)A) module to obtain materials modulus information under sample deformation applied.
The contract for the supply of the equipment was signed on 03.02.2015 for a price within the allocated resources. On 15.04.2015 the equipment was delivered and hardware as well as software installation was completed.
The instrumentation consists of following modules:
- Dynamic mechanical analyzer DMA Q 800 (TA Instruments): mechanical section enclosure; clamp assembly and a set of clamps: Cantilever (Single/ Dual), Three-point bend, Compression, Tension, Shear sandwich; furnace assembly
- Air chiller system ACS-3 (TA Instruments);
Modes of DMA as well as clamping guide for different sample types are listed below:
1. Cantilever (Single/ Dual):
- Dual cantilever is suitable for highly damped materials and to study cure of supported materials.
- Single cantilever is useful for most neat thermoplastics and stiffer materials.
2. Three-point bending - for medium to high modulus materials.
3. Compression - for low to medium modulus materials.
4. Shear sandwich - provides shear moduli: G*, G', G" and G(t). Ideal for highly damped soft solids.
5. Tension - for thin films and fibers.

The DMA purchased is a material characterization tool capable of determining the viscoelastic properties of materials as a function of temperature (from -100oC to 500oC) or frequency (from 0.01Hz to 200Hz). A broad range of parameters such as storage modulus, loss modulus, glass transition, crystallinity, cross-linking effects, fatigue and other transitions can be determined with the DMA.

A laminar flow cabinet for purification of the air in the room where the DLS/SLS goniometer is located and a hood necessary for the preparation of samples for analysis in organic solvents were also acquired. They were delivered on 27.11.2015.

Another specific result of the WP3 implementation is the training of IP-BAS staff of the (young researchers, technicians and PhD students) on equipment exploitation.
Training on GPC/MALS, TGA/GC/MS, DMA and DLS/SLS goniometer and Zeta measuring module was

conducted on 06.11.2014 29.09.2015 27 – 28.04.2015 26.11.2015 and 1-5.02.2016 respectively. All trainings were conducted under the scheme –firstly, theoretical presentation delivered by WP 3 leader and the experienced technicians employed under the project POLINNOVA and secondly, practical training - analyses of standard samples as well as research samples synthesized at IP-BAS. Concise description of the training of the individual apparatus is given below:

Training on GPC/MALS equipment:

A) The theoretical session: basic HPLC/GPC and light scattering theory; technical specifications of the GPC/MALLS equipment – HPLC/GPC and MALLS modules, discussion on the conditions for the assay and feasible determination (degree of branching, Rg, Rh, dn/dc, batch mode, cmc, etc.); guidelines of conducting routine analyses and/or specific determinations – coupled GPC/MALLS analyses, batch mode light scattering technique; determination of absolute MM with multiangle static light scattering (MALLS) in stationary mode ("batch mode"); SEC/MALLS/DLS - specific applications of the combined method: complexation polymer/ biological macromolecules.

B) Practical training: PSt standard and poly(allyl glycidyl ether) - polyglycidol coplolymer sample synthesized at IP-BAS were run.

Training on TGA/GC/MS equipment

A) The theoretical session of the training included - introduction to the TGA PE4000, GC PE Clarus600, MSD PE SQ8 and RedShift valve system: technical specifications of hardware of the acquired equipment; library search using NIST Spectra Library for qualitative analysis; guidelines for conducting routine analyses and/or specific determinations – coupled TGA/GC/MSD analysis, analysis of liquid samples with GC/MSD.

B) Practical training: a set of (co)polymers synthesized in IP-BAS - poly(dimethyl acrylamide)-block-polystyrene and poly(butadiene phenylurazole) were run and analyzed during the practical course.

Training on DMA apparatus

A) The theoretical session of the training included: technical specification of the DMA modules, hardware and basic software; guidelines for operation with ACS-3 chiller; modes of DMA & Clamping guide for different sample types.

B) Practical training: calibrating the DMA instrument; choosing a clamp set; selecting the operating mode; mounting sample; maintaining the instrument. Standard materials were run and tested: stiff indium and zinc standard samples; polycarbonate, poly(acrylonitrile-co-butadiene-co-styrene) (ABS) and poly(ethylene terephthalate) (PET) standard polymeric samples and weak film polymer material sample formulated in IP-BAS.

Training on DLS/zetasizer/dndc equipment

A) The theoretical session of the training included: basic light scattering theory; operational and technical specifications of the light scattering equipment – goniometer, zetasizer and DNDC modules, hardware and basic software's; guidelines of conducting analyzes: doing routine analyses and/or specific determinations – dynamic light scattering, static light scattering techniques and DNDC measurements;

B) Practical training: standard solutions of different concentrations were run and analyzed during the practical course, namely: high molecular weight PSt standard.

The presentation of the new apparatuses on the website of the Institute has been done as well as demonstrations of the equipment, included in the days of the open doors of the Institute conducted annually.

WP4. Unlocking the innovation capacity of IP-BAS

Work package 4 included different activities aimed at unlocking the innovation potential of IP-BAS for developing advanced polymers and high added value polymer based materials. The activities were structured in six tasks with specific objectives.
Task 4.1. Organization of workshops and training the IP-BAS staff on innovations and intellectual property development and rights.
Task 4.2. Recruitment of an IPI manager and establishment of an expert unit on intellectual property and innovations management.
Task 4.3. Conducting roundtable discussions with the innovation policy makers.
Task 4.4. Establishing favorable conditions for international partnership for co-exploitation of results.
Task 4.5. Preparation of communication materials and activities for promotion of IP-BAS innovation capacities.
Task 4.6. Elaboration of a strategic development plan for innovations, management and protection of IP-BAS intellectual property.

A training course on IPR issues provided basic knowledge on inventions/patents, utility models, industrial design, marks and geographical indications, as well as practical training on patent writing, patent search, IPR issues concerning the collaborative projects. The course was conducted by professionals from the National Patent Office and from abroad.
Mr. Bart Hommez, a Technology and Business Developer at the TechTransfer Office at the Faculty of Sciences of the Ghent University (a partnering organization within the project) provided additional training on patent writing and the role of a technology transfer office during his visit (from June, 01 to June, 04 2015) at IP-BAS. Training events organized by the European Patent Academy, World Intellectual Property Organization (WIPO) and the Patent Office of Bulgaria were attended by the IP expert recruited in the project and the WP4 leader.
The planned activities included also training on Horizon2020 - the EU Framework Programme for Research and Innovation. The training course was run from 17 to 19 February, 2014. It included lectures and practical training on proposal writing and management. Twenty five persons of the research staff of the Institute, including key scientists of each of the structural units (Laboratories) of the Institute, participated in the training.
Important milestones in the project were the two workshops organized within the WP4. The first one was dedicated to Polymer Materials Research & Innovations. The event took place from 30-rd October to 1-st November, 2013. The scope of the workshop encompassed lectures on priority topics in polymer research, as well as on IPR management and the polymer industrial branch in Bulgaria. The workshop was attended by 52 participants - 9 invited lecturers, 37 from the research staff of the Institute of Polymers and 6 PhD students.
The topic of the second workshop was on Challenges for academia and industry in realizing the Bulgaria 2020 Innovation Strategy. Representatives of the research and industrial sector participated, as well as of the Ministry of Economy and Energy, local authorities and other stakeholders. The workshop provided a forum for a dialog and interaction between different players and decision making bodies in the national research and innovation area. The Institute presented its Innovation strategy and received positive opinions in support of the efforts of the staff towards implementation of the research achievements.
The recruitment of an IPI manager turned to be an important step towards enhancing of the innovation activities at the Institute. The position was split and two experts with complementary expertize were

recruited:
• Prof. Kostadinov with experience in technology transfer took the responsibility for coordination of the activities for building up a platform for sustainable innovation developments and the interactions with industry and innovation policy makers.
• MS R. Halatcheva holds a master degree in IPR. She assisted the staff in patent search and preparation of the patent applications, in drawing the internal rules for protection of the IP at the Institute.

Besides the recruited IP manager and expert more staff was involved in the activities of WP4 for preparation of communication materials and promotion of IP-BAS innovation potential. This included organization of a meeting with members of Branch (Bulgarian) Association Polymers during the International Plovdiv Fair, October 2013, as well as participation at the EuroNanoForum (18 - 20 June 2013, Dublin), at the conference “Innovation and Entrepreneurship 2014” March 2014 (Sofia, Bulgaria), at a workshop and brokerage event “Green Chemistry”, Burgas, Bulgaria, 6th-9th April 2014, at a conference organized by the Regional Academic Center in Sliven on 24-25 March 2014, etc.
A core task of the WP4 was the elaboration of a strategic development plan for innovations, management and protection of IP-BAS intellectual property. A package of three documents was prepared, widely discussed and adopted:
(i) Research priority areas of the Institute of Polymers
(ii) Internal Rules on the Creation, Registration, Protection and Management of the Intellectual Property of the Institute of Polymers.
(iii) Strategy for increasing the innovation potential of the Institute of Polymers.

As a result of the innovation activities patent and utility model applications were filed:
• Nanosized polyelectrolyte associates with antitumor activity, method for their preparation and use thereof, patent appl. No. 111326, publ. date 30th April 2014. Priority date: 18th October 2012. The application was published in the Official Bulletin of the Patent Office of the Republic of Bulgaria (Bulletin No. 4/30.04.2014). The current legal status of the application is that it’s under examination.
• Method for neutron detection and neutron detector thereof, PCT appl. No. PCT/BG2014/000024. Priority date: 26th June 2014. The application is expecting its first publication and entry into National/Regional Phase after successfully passed formal examination and preliminary search.
• Method for preparation and stabilization of concentrated colloidal dispersions of silver nanoparticles in the presence of poly(oxyalkylated) Calixarenes, process for their drying, redispersion and use, patent appl. No. 111935. Priority date: 20th February 2015. The application is expecting its first publication in the Official Bulletin of the Patent Office of the Republic of Bulgaria.
• Composition of water-soluble form of propolis, utility model appl. No. 3103. Priority date: 30th September 2015. The application is under formal examination.

Efforts on strengthening or establishing partnership with industrial representatives resulted in:
• Two Agreements for joint research and innovation activities were signed („Geotechmin“ LTD and Chemical Products Ltd).
• Two project applications were submitted in response to a call of the Bulgarian Innovation Fund with an industrial partner “Energeo” LTD which is part of „Geotechmin“ LTD.
• A contract with Kozloduy Nuclear Power Plant for consultancy and analytical services
Three project proposals to HORIZON 2020 programme R&I calls were submitted:

1. Special Nuclear Materials Detection and Evaporation Based Interrogation Technology for Large Volume Freight
Proposal number: 653745
Proposal acronym: ENTER-EURO-GATES
Call identifier H2020-BES-2014; Type of action RIA
Coordinator IP-BAS, Assoc. Prof. Neli Koseva, PhD
Submitted 2014
2. Coated Metallic Bipolar Plate Based Low-Cost Stack with Low-PGM-MEA for Automotive Applications
Proposal number: 700497
Proposal acronym: CoMet Stack
Team leader from IP-BAS: Assoc. Prof. Vesselin Sinigersky, PhD
Submitted 2015
3. Advanced Nano Improved Material for Automotive
Acronym: A.N.I.M.A.
Proposal number: 686318
H2020-NMP-PILOTS-2015 (NMP-02-2015)
Team leader from IP-BAS: Assoc. Prof. Neli Koseva, PhD
Submitted 2015

The main results from the diverse activities to achieving the specific objectives of WP4 can be summarized as follows: increased intellectual property awareness of IP-BAS staff, more intensive exchange of innovation knowledge and experience with the twinning organizations, motivation towards implementation of the research results and rules for their exploitation, wider communication of the research and innovation potential of the institute with industry and other stakeholders, developed and adopted strategic documents for realization of the innovation potential of IP-BAS.

WP5: Dissemination and Communication Activities

The activities conducted within the frame of WP5 aimed to increase the visibility of IP-BAS excellence and the awareness of society about IP-BAS achievements. Various actions for dissemination, marketing and promotion of IP-BAS results to the academic circles, industry, stakeholders and general public were conducted.
The core activities associated with dissemination of the most recent research results of IP-BAS researchers involved organization and participation at different international and national conferences and scientific events, and publication of articles in high-impact journals. IP-BAS staff organized the international conference “Challenges in Science and Technology of Polymer Materials” in Bansko, Bulgaria, in May 19-23, 2015. A web-site containing detailed information about the conference scope, venue, important dates, programme, topics, speakers, registration, accommodation, transportation, etc., was launched by the organizer (http://challenges2015.polymer.bas.bg/). In addition, a conference flyer was prepared and distributed via e-mails among partnering organizations, personal contacts and many other researchers involved in polymer science from Bulgaria and worldwide. One hundred and nine participants from 16 countries from Europe, USA and Japan, presenting 27 organizations took part in the conference. The event was divided into six sessions, including plenary lectures, keynote lectures and oral presentations. In addition, poster communications were presented in two sessions. Overall, 6 plenary

lectures, 7 keynote lectures, 33 oral and 52 poster presentations were delivered. Many new results and ideas were reported for the first time by scientists from leading teams in polymer science, making this event one of the important forums in the field of polymers and polymer materials in 2015. After the two poster session a “best poster award”, donated by Aldrich Materials Science (Germany), was given to Gyuldjan Yakub, PhD student at IP-BAS.

Another important scientific forum organized annually by IP-BAS was addressed to PhD students, post-docs, and other young researchers. During the project implementation Fourth, Fifth and Sixth poster sessions “Young scientists in the world of polymers” were held in 2013, 2014 and 2015, respectively. The poster sessions focused on the recent outcomes of young scientists working in different fields of polymer science. The sessions attracted a constant number of participants from the leading research institutions in polymer science in Bulgaria. The thematic areas covered modern tendencies in polymer research and interdisciplinary fields concerned with application of polymer based materials. The format of poster presentation allowed fruitful discussions and exchange of knowledge among the young researchers and making contacts for further collaboration. Each participant received a certificate for participation on the poster session and a booklet including all posters presented. Awards for the best poster presentation were given by the organizers.

Dissemination of the most recent advances of IP-BAS researchers was achieved by attending different international and national conferences and workshops. During the project implementation, the scientist from IP-BAS supported by POLINNOVA project delivered 2 keynote lectures, 10 invited lectures, 20 oral and 86 poster communications at 57 international and 4 Bulgarian conferences, congresses and workshops. Owing to the EU funding, the overall number of presentation of IP-BAS members at scientific forums per year was constantly increasing during the last 4 years, achieving 96 contributions for 2015 (without the poster sessions held at IP-BAS). The contributions for 2014, 2013 and 2012 were 68, 66 and 62, respectively.

Another core activity for dissemination of research achievements is the publication of articles in specialized journals. The number of paper published by IP-BAS scientists in 2015 and 2014 was ca. 18.5 % higher than those in 2013, and 27.5 % higher than the average number taken as indicator (40 paper per year). The publication rate for the second period of the project was ca. 2 % higher than that of the first 18 months. A constant increase in the number of the papers published in journals with impact factor was registered. The number of joint publications with partnering organizations was 26.7 % more than those taken as indicator (15 articles).

The dissemination and communication activities oriented to the general public and business community conducted within WP5 included issue and dissemination of annual IP-BAS booklets and brochures, organization of Open days, interviews in mass media, and meetings with companies. Annual booklets, both in Bulgarian and English, covering all range of activities of IP-BAS researchers for 2012, 2013, 2014 and 2015 were issued. The booklets included general information about the Institute, current research topics, achievements and publications, current projects, new facilities acquired, PhD students, most important meetings and events, relationship with the industry and international partners, etc. The important projects of IP-BAS were described as well, including special focus to the POLINNOVA project. The full text of IP-BAS yearbooks were published regularly on the Institute web site. During the project implementation two brochures were prepared and distributed to targeted companies. In the first brochure general information about the research activities and facilities of IP-BAS as well as the POLINNOVA project was presented. The second brochure provided information for the current scientific equipment at IP-BAS, including the main characteristics of each apparatus and its application in practice. These

brochures aimed to attract Bulgarian companies to exploit IP-BAS facilities for identification, characterization and technological control of polymer materials as well as for expert opinion and consultancy services.
Traditionally, the Open days were organized every year on the eve of the Day of Bulgarian Letters and Culture (24 May). The Institute was visited by representatives of Bulgarian industry, students from Bulgarian universities and high schools and colleagues from the Bulgarian Academy of Sciences. On these events, various scientific achievements of IP-BAS scientists in the field of new polymers and polymeric materials were introduced to the visitors, as well as different forms of training at IP-BAS (specialized lectures, laboratory internships, preparation of master theses and dissertations) that young people can receive in the field of polymers. Together with presentations of the main research activities of the six laboratories at the Institute, some attractive scientific experiments and demonstrations with modern equipment were carried out. The Open Days were highlighted by “Darik Radio”, the sites of POLINNOVA, Institute of Polymers, Bulgarian Academy of Sciences and several popular Bulgarian sites. In this line, a team from IP-BAS was responsible for keeping close contacts with the media to promote the importance of advanced polymer materials. Interviews for the most popular Bulgarian mass media were given by the director Dr. N. Koseva (BNT1, BTV, Darik radio, BNR, BNA, Azbuki newspaper), Corr. Member of BAS I. Rashkov (NovaTV, BTV), Prof. P. Petrov (BTV, Azbuki newspaper), Dr. P. Tuleshkov and Dr. Ph. Ublekov (TV+). The interviews addressed important topics from the everyday life to the contribution of the scientific community for solving fundamental problems. In addition, 18 communications and articles describing the IP-BAS expertise and activities (including 5 articles highlighting the POLINNOVA project) were published on different international and Bulgarian web-sites and in the Journal of BAS and the Bulletin of BAS.
Dissemination of IP-BAS excellence and know-how to industry were also conducted by participation in professional forums and meetings with companies. The director of IP-BAS Dr. Neli Koseva presented the Institute at EuroNanoForum, (Dublin, Ireland), International Plovdiv Fair (Plovdiv, Bulgaria) and the Conference "Innovation and Entrepreneurship 2014" (Sofia, Bulgaria). The opportunity to commercialize products and technologies developed at IP-BAS were discussed with representatives of the Bulgarian companies Energeo and Prista Oil and the Turkish company Teklas.

WP6. Evaluation of IP-BAS research potential and innovation capacities upon POLINNOVA completion
The focus of this work package was on the evaluation of IP-BAS performance as a whole at the end of the POLINNOVA project. The ex-post evaluation was performed by three external international independent evaluators nominated by the European Commission: Prof. Maria Letizia Focarete (Chair), Prof. Miroslawa El Fray and Prof. Manuel Coelho. The WP objectives were achieved by organization of two on-site visits of the group of experts and one workshop for discussion and communicating the evaluation results and recommendations derived.
Prior the evaluators’ first on-site visit they were provided with information about the POLINNOVA project (DoW, reports, deliverables, results, documentation and materials concerning the project implementation) as well as information about the IP-BAS structure, human resources, research topics, etc.
The first on-site visit (3 days) of the group of experts at the IP-BAS was held from 8th to 10th February 2016. During that visit the Coordinator of the project and Director of the IP-BAS presented the Institute and gave an overview of the POLINNOVA project. The WP Leaders presented in details the project results and particular outcomes from the implementations of the work packages, and the project achievements and impact. The experts group met the Heads and staff members of each of the six Laboratories at IP-BAS, administrative personnel, as well as with the recruited experienced researcher and technician, and

were provided with all needed documentation to estimate the prospects of further research and innovation activities of IP-BAS. The experts visited each Laboratory, interviewed the researchers and PhD students, and inspected on-site the infrastructure and equipment (not only acquired within the POLINNOVA project). The evaluation took into account several indicators: human resources, infrastructure and equipment, research results, national and international collaborations, connections and partnership with regional stakeholders, organizational and management structure. Based on the collected fact-findings and delivered documentation the group of international independent experts prepared the evaluation report, including conclusions and recommendations for the development strategy of the Institute and its future activities at EU level.
The second on-site visit and workshop for communicating the evaluation results was held at the IP-BAS from 23 to 25 of March 2016. The purpose of the workshop was to discuss the recommendations presented by the EC experts and the updated SWOT analysis. The workshop was attended by the experts' team, four Advisory Board members, the Management Group of the project and the Scientific Council of the Institute. During that workshop, the Advisory Board members made suggestions concerning the forward-looking elements of the report – strategic guidance, recommendations for the development strategy of the IP-BAS and its further activities at EU level, networking and collaboration. The experts agreed with the suggestions and useful inputs made by the Advisory Board members and the final version of the Evaluation report was approved.
The evaluation report contained 3 sections including forward-looking section with an updated SWOT analysis. The group of the experts was very favourably impressed by the research quality produced by IP-BAS during the period under evaluation. The observations discussed and reported by experts team show that IP-BAS has continuously improved its performance over recent years. The POLINNOVA project has fulfilled all planned tasks and has achieved all its objectives. Moreover, the project was highly relevant for the strengthening of the research capacity and innovation potential of the Institute. The evaluators expressed confidence that the scientific production will be further increased with the new facilities/equipment provided by the POLINNOVA project. However, a further effort is needed in order to establish sustainable collaboration with the regional industry and enable joint participation to European programmes. The evaluators' opinion is that IP-BAS has reached the level of a Centre of excellence as academic organization in advanced polymer materials research, development and innovations at national level. That also extends the positive impact of the POLINOVA project. The Institute is now a member of a wide international research network gathering European research institutes and universities and it is therefore well integrated in ERA with established scientific collaborations with other EU research teams. The final conclusion of the EC experts was that the main challenge is to keep the gained advancement and development of IP-BAS, in order to enhance the competitiveness and ensure sustainability in research and innovation performance.

WP7. Project management
The POLINNOVA management actively provided appropriate conditions for undisturbed and timely implementation of all planned project activities and tasks. The efforts were directed to the effective administrative support of the project activities, coordination and motivation of the entire IP-BAS staff to enable successful project implementation within the provided budget.

Project Management Group (MG):
Assoc. Prof. Neli Koseva - Project coordinator and WP4-leader

Assoc. Prof. Ivaylo Dimitrov -WP1;
Prof. Stanislav Rangelov - WP2;
Assoc. Prof. Christo Novakov - WP3;
Assoc. Prof. Petar Petrov - WP5;
Assoc. Prof. Olya Stoilova - WP6;
Assoc. Prof. Darinka Christova - WP7;
Mrs. Lili Vucheva - financial manager of IP-BAS, consulting and supporting MG decision making on financial and administrative issues.

POLINNOVA Management Group was in charge of the project legal, administrative and financial issues and assists the mobilization of the manpower and financial resources according to the execution plan, in monitoring and reporting the overall project activities as well as in the interaction with the Project Officer and European Commission. Management group succeeded to ensure appropriate management infrastructure for the project, to coordinate and motivate the staff efforts and to enable undisturbed project implementation. The Management Group meetings were convened at regular basis – generally once per month and in addition ad hoc meetings were held to handle specific issues and in order to speed up decision making on the important project tasks/activities. The Management Group organized two important events – the kick-off and closing meetings. These events were used to promote the projects aims and activities, to disseminate the achieved results, to communicate the Evaluation report and the expected impacts to the scientific community, representatives of the Ministry of education and science, local authorities and other stakeholders.
The POLINOVA consortium partners include six research groups from five different European countries active in the development of advanced polymer materials. The Branch Association Polymers was also involved as a coordinator of more than 40 small and medium size Bulgarian enterprises – potential users of the research and innovation outcomes of the Institute.
• Polymer Chemistry Research Group, Department of Organic Chemistry, Ghent University, Belgium
• Center of Innovation and Research in Materials & Polymers, University of Mons, Belgium
• Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation, Greece
• Centre of Polymer and Carbon Materials, Polish Academy of Sciences, Poland
• Department of Chemical Engineering, University of Castilla-La Mancha, Spain
• School of Pharmacy, University College London, UK
• Bulgarian Association Polymers, Bulgaria
The POLINNOVA project Advisory Board includes nine renowned scientists in the field of polymer science from eight European countries:
• Prof. Andrzej Dworak, Center of Polymer and Carbon Materials – Polish Academy of Sciences, Zabrze, Poland
• Prof. Dr. Filip Du Prez, Department of Organic Chemistry, Ghent University, Belgium
• Prof. Juan Francisco Rodrigues, Department of Chemical Engineering, University of Castilla-La Mancha, Spain
• Prof. Dr. Stergios Pispas, Theoretical and Physical Chemistry Institute - Athens, Greece
• Prof. Dr. Steve Brocchini, School of Pharmacy, University of London, UK
• Prof. Dr. Klaus Müllen, Max-Planck Institute for Polymer Research - Mainz, Germany
• Prof Jose M. Kenny, European Centre of Nanostructured Polymers, Italy; ICTP-CSIC
• Prof. Dr. Philippe DUBOIS, University of Mons, Belgium

• Prof. Sebastien Lecommandoux, University of Bordeaux, France

The Advisory Board was constituted at the outset of the project and its first meeting was called together with the POLINNOVA kick-off in November 2012. A total of four Advisory Board summits were carried out, all of them being associated to important project events such as workshops and conference.
The role of the board was defined in the document “Advisory Board’s mission and function” approved with consensus during the first meeting. During the project implementation the Advisory Board assisted the Management Group to achieve project strategic objectives by providing insight, advice, and support relative to strengthening IP-BAS research and innovation potential, capacity building and development and fundraising endeavors while providing links to the scientific and stakeholder communities. Advisory Board members contributed substantially in the formulation and update of the research and innovation strategy of IP-BAS, discussing the prospects for up-scaling the Institute’s potential and tracing specific measures to be undertaken in order Institute to become a dynamic centre for innovations capable of sustaining regional or national growth.
Advisory Board’s members assisted in the selection of experienced researchers, technicians and IP manager appointed on the POLINNOVA project. Priorities and strategy during the upgrade and diversification of the research infrastructure were also discussed with the Advisory board members especially the equipment to study the solution properties of polymer colloids and nanoparticles. The Advisory Board members contributed to the development of key project documents as Strategic Development Plan for innovations, management and protection of IP-BAS intellectual property and the updated IP-BAS SWOT analysis. Six of the Advisory Board members being representatives of the twinning partnering organizations provided additional input to the establishment of new and strengthening of the existing strategic partnerships with prominent European research centers, participating in the workshops and dissemination events organized by the Institute.
As an important factor for the successful dissemination of project results and promotion of IP-BAS achievements the website of POLINOVA project was maintained and regularly updated with project news, outcomes and events. It contains information on all important project activities and developments as well as achievements of the staff. In such way it contributes for increasing the awareness of the scientific community and related industrial circles about the project implementation and latest or upcoming events.
Potential Impact:
The results obtained through the various activities fulfilled within the POLINNOVA project are the basis for a long-lasting impact covering broad range of aspects outlined in the Capacities Work Programme. They concern further development of the research capacity and innovation potential of the Institute of Polymers, as well as the socio-economic impact at national and European level.

Upgraded RTD capacity and increased quality of research carried out at the Institute of Polymers

The development of research potential in terms of human capital is of crucial importance for sustainable and competitive research outcomes. Therefore the improved and diversified skills and qualification of the research staff are key factors for increased capabilities and productive performance. The realized transnational and trans-disciplinary mobility via secondments with six leading European research organizations clearly contributed to the development and widening of the existing and gaining new research experience. The knowledge exchange and transfer resulted in initiation of new research lines and plans for joint project applications. The Institute received encouragement and complete support from the

twinning organizations for its efforts to reinforce the research excellence. The collaboration with our outstanding partners turned to be very fruitful in terms of mutual research activities and complementary knowledge and expertise. The efforts resulted in increased number and quality of joint scientific publications with our partners, presentations of joint research at various international scientific forums and establishment of multi-partner contacts for successful participation in research activities at EU level.
The visits of leading scientists from the twinning organizations who shared their vanguard research experience and good practice in science management with IP-BAS team leaders and researchers has improved the research competence and development of leadership skills. The attraction, development and training of talented researchers to ensure leadership continuity has always been a priority of IP-BAS management, which has been facilitated by the activities within the project. The intensive networking and exchange of know-how and expertise opened prospects for providing cutting edge scientific results and better integration of IP-BAS in the European Research Area.
The IP-BAS human resources have been enhanced by recruitment of 10 experienced researchers within the project. They possess high qualification in fields of polymer science coherent with the strategic research and innovation objectives of IP-BAS. Their active involvement into the research and innovation activities contributed very much to enhancing RTD and S&D potential of the institute. The experienced researchers shared their knowledge and expertise with the staff and PhD students, promoting interdisciplinary investigations thus boosting the research quality of IP-BAS at a higher level. They also participated in networking and dissemination activities, coauthored 28 research papers, 1 patent application and 18 presentations at scientific forums. In addition the technical and analytical expertise was enhanced via recruitment of 2 experienced technicians, who were actively involved in the installation of the instruments, staff training, developing analytical protocols, consultancy services, etc.
Upgrading the research infrastructure at IP-BAS enhanced the RTD capacities for complex materials development and analysis – a result affecting the overall performance of the institute and having also socio-economic dimension. A GPC line equipped with a triple RI/UV/LS detector combination was acquired for determination of polymer molecular mass characteristics, control of the polymerization processes, as well as parameters of aggregates/particles formed in solution. The investigations of polymer behavior in solution and colloidal systems have been supported via purchasing equipment using static/dynamic and electrophoretic light scattering - DLS/SLS goniometer and Zeta measuring module. Coupling of the existing TGA instrument with gas chromatograph/mass spectrometer detector extended the capabilities for determination of material structure and composition, analysis of the products of oxidation or decomposition under heating, presence of impurities or residual solvents, etc. A new instrument for complex physical and thermomechanical characterization and testing of polymer materials was acquired thus assuring precise study of their viscoelastic properties as a function of temperature or frequency.
The extended and modernized research facilities broaden the research scopes and competence of IP-BAS for complex analysis and thorough characterization of multifunctional polymer materials – determination of the molecular mass and molecular mass distribution, the size and shape of nanoparticles or micelles/aggregates in colloid solutions as well as their zeta potential, the behaviour of polymer materials in solid state and in melt. The equipment provides the analytical tools for studying the effect of different parameters (concentration, pH, ionic strength, temperature, frequency) on materials performance, i.e. degradation, complexation, stability of aqueous dispersions, etc. The enhanced analytical capacities meet the research priorities of the institute and strengthen its potential for innovative research and establishment of fruitful cooperation with related industries manufacturing plastics and composites, food

and pharmaceutical products, etc.
In addition, RTD competence has been enhanced through training on equipment exploitation. Young researchers and PhD students from the Institute underwent training both theoretical and practical, on operating the newly acquired instruments. This is a real ground to increase their qualification and assist their career development.

Innovation Impacts

The improvement of research capabilities in terms of human potential and specialized infrastructure, as well as the strong partnership with knowledgeable organizations is the fundament for unlocking and further development of the IP-BAS innovation potential. The Intellectual Property and innovation management have been boosted with the recruitment of an innovation manager and an IP expert. The workshops and training courses on protection of intellectual property rights have augmented the innovations awareness of IP-BAS staff. The measures that have been undertaken for wide dissemination of the research output and innovation potential of the Institute enhanced the interactions with industrial representatives. The latter will have a stimulating effect on the added value innovative research.
The Strategic development plan for innovations, management and protection of IP-BAS Intellectual Property has been designed to facilitate the accomplishment of research ideas and delivery of innovative outcomes. It is composed of three important documents: (i) Research priority areas of the Institute of Polymers; (ii) Internal Rules on the Creation, Registration, Protection and Management of the Intellectual Property of the Institute of Polymers and (iii) Strategy for increasing the innovation potential of the Institute of Polymers. This package of documents has been discussed and adopted to regulate and stimulate the innovation activities, to promote the innovators at the Institute. Being coherent with the priorities set in the National Innovation Strategy for Smart Specialization all undertaken activities and achieved results build up a platform for sustainable innovations development and commercialization of our products, services, and technologies.

Further integration into the ERA

The implementation of the POLINNOVA project has been effectively contributing to the further integration of IP-BAS into the ERA, namely by upgrading its material resources and facilities; networking with prominent European research centers; enhanced mobility of the staff; creating environment to promote the career development; adopting vanguard innovation policies and improving the dialogue with society.
The research infrastructure of IP-BAS has been upgraded to facilitate up-to date investigations in the field of polymers and polymer materials. The twining with the six leading academic institutions provided not only opportunities to boost the qualification of IP-BAS staff through secondments exchange, but for broadening its research competence with new scientific scopes as well. Besides raising the scientific production to a higher level (most of the articles co-authored with our partnering research teams are in journals with a high impact factor), the intensive collaboration between the Institute and its partners opens new prospects for further joint initiatives by submitting a joint projects within the European Horizon 2020 and COST programmes.
Key steps to increasing the competitiveness of IP-BAS have been the adequate policies for Protection and Management of the Intellectual Property generated at the Institute that included training courses,

workshops, adopting Research Priorities, Internal Rules and Innovation Strategy in conformity with the National Strategy for Smart Specialization, the latter being harmonized with the EU growth strategy Europe2020.
A benchmark of the integration of IP-BAS into the ERA has also been its increased visibility and reputation amongst the academic circles at home and abroad. The workshop “Polymer Materials Research&Innovations” and the international conference “Challenges in Science and Technology of Polymer Materials” organized by the Institute attracted prominent scientists who presented their latest achievements and were involved actively in the discussions on the results reported by IP-BAS and other participants. The visibility of the POLINNOVA project has improved the potential of the Institute as a reliable partner in joint research and project development at European level.
The research and management potential has been mobilized to generate new ideas and partnerships for successful participation in the EU programmes. The close co-operation with the partnering organizations and continuing exchange of good practices, experience and know-how, technology transfer, stimulation of a multi-national approach have augmented the IP-BAS competence in developing proposals. IP-BAS was successful in a number of projects within the Operational Programmes ("Development of the Competitiveness of the Bulgarian Economy 2007-2013" and „Human Recourses Development” 2007-2013) that strongly complemented and acted synergistically with the POLINNOVA project. Furthermore, proposals in response to H2020 calls and COST actions have been prepared and submitted.

Impact from dissemination and communication of research results
During the project implementation a communication plan for increasing the visibility of IP-BAS excellence was realized. The access of the scientific and professional communities to the achievements of IP-BAS was increased as a result of the intensified publication activities and presentations at scientific events. The visibility campaign was also strengthen by the organized conference, meetings and open days, and dissemination of brochures and other printed materials oriented to the general public and business community.
During the POLINNOVA project 175 scientific papers have been co-authored by scientist of IP-BAS and published/accepted for publication. The publications include 165 journal and conference articles and 10 books and book chapters. 158 articles were published/accepted in peer-reviewed journals. 29 of the papers appeared in open access journals or have open access status. Four invited articles received financial support by the POLINNOVA project for open access status. Overall 137 lectures and communications have been presented at 67 national and international scientific forums, including 3 plenary lectures, 11 invited and keynote lectures, 24 oral and over 100 poster presentations. Complete lists of the publications and conference papers are given in Deliverable 7.4.
In 2013, 2014 and 2015 at the traditional annual poster sessions “Young scientists in the world of polymers” organized with the support of the POLINNOVA project 54 scientific posters have been presented by the IP-BAS young researchers and students. During the “Polymer Materials Research and Innovations” workshop held in Belchin Garden Hotel in 2013 scientists from IP-BAS delivered 6 lectures. These presentations on key research topics at the Institute highlighted recent achievements of the research staff. Another 6 oral communications together with 12 poster presentations were delivered at the International conference “Challenges in Science and Technology of Polymer Materials” held in 2015 in Bansko.
The dissemination of research outcomes by publishing in high-impact journals and presentations at world-renowned scientific events will have a long-lasting effect on the popularity and reputation of IP-BAS in the

academia. On the other hand, the benefits for the researchers of IP-BAS from their participation at such conferences were two-fold - direct benchmarking with the recent tendencies and research done in the most prominent polymer centers and establishment of new scientific contacts, which are expected to have an impact on the further integration of the Institute into the ERA. The generation of new collaborations and initiatives might grow into new cooperation works and projects and to set-up long-lasting strategic partnerships with research organizations in ERA.
The enhanced knowledge of IP-BAS staff on IPR issues stimulated the innovation activities and three patents and one utility model applications were filed:
1. Nanosized polyelectrolyte associates with antitumor activity, method for their preparation and use thereof. Patent appl. No. 111326, publ. date 30th April 2014. Priority date: 18th October 2012 (Published in the Official Bulletin of the Patent Office of the Republic of Bulgaria: Bulletin No. 4/30.04.2014)
2. Method for neutron detection and neutron detector thereof. PCT appl. No. PCT/BG2014/000024. Priority date: 26th June 2014 (published)
3. Method for preparation and stabilization of concentrated colloidal dispersions of silver nanoparticles in the presence of poly(oxyalkylated)calixarenes, process for their drying, redispersion and use. Patent appl. No. 111935. Priority date: 20th February 2015. (Current status: expecting first publication)
4. Composition of water-soluble form of propolis. Utility model appl. No. 3103. Priority date: 30th September 2015 (Current status: application under formal examination)

The establishment of spin-off companies was not a target outcome of the project, nevertheless the Management of the Institute has identified among the industrial properties created the one with a market potential. The establishment of a spin-off company for developing a commercial product, i.e. nutritional supplement based on the utility model “Composition of water-soluble form of propolis”, and its market realization is under consideration and included in the Institute’s innovation plan. The success of such company will have a socio-economic effect in several aspects: (i) the developed composition is based on a natural product produced in Bulgaria and can be regarded as an added value product; (ii) its application is directed to a broad range of population, i.e. from children to elder people; (iii) it is a health improving product that can be administered for prophylactic purposes;. (iv) the obtained results could be used for further development of a pharmaceutical product; and (v) the company could afford employment to qualified professionals.

The POLINNOVA project was designed as a multidisciplinary set of actions, targeted not only at the scientific community and academia, but also at industrial and business representatives, stakeholders, policy makers and the general public. Besides dissemination of knowledge and transfer of know-how among the researchers, specific events for non-experts and creation of opportunities for dialogue and discussion with the representatives of business, stakeholders and policy makers have been organized. The communication activities to the general public included: Open Doors Days in 2013, 2014 and 2015, interviews for different media (Bulgarian News Agency, newspapers, TVs and radio), popular articles in press. Eleven articles describing the IP-BAS expertise and activities, including 5 articles highlighting project POLINNOVA, were published in journals or on different international and Bulgarian web-sites. The internet and media coverage aimed not only to present IP-BAS achievements but also increase the public trust in scientific and technological breakthroughs thus providing more favorable environment for innovations. The dissemination and communication activities oriented to the general public and business community included issuing of annual IP-BAS booklets. The booklets give general information about the

Institute, the six research laboratories at IP-BAS presented through their current research topics, achievements and publications, projects, particularly for the POLINNOVA project, and events taken place at the Institute. There are sections devoted to the tuition and innovation activities at IP-BAS, the relationship with the industry and international partners, the participation of the Institute in operational programs and the impact of our activities and expertise for the academia and public community. The booklets have been distributed as hard copies to a targeted audience, as well as published on the POLINNOVA project website.
The enhanced awareness of general public and industry about IP-BAS capacity resulted in better exploitation of IP-BAS analytical facilities and staff expertise regarding specific consultancy services on polymer based materials. The improved communication with industrial representatives will also open opportunities for facile commercialization of know-how, products and technologies developed at IP-BAS.

The socio-economic impact and the wider societal implications of the project
The modernized IP-BAS scientific infrastructure can be used both for the research conducted at IP-BAS as well as for innovation activities and analytical services. Information about the new equipment and the staff expertise is available on the website of the Institute. Demonstrations of the equipment, included in the days of the open doors have been conducted thus attracting undergraduate and graduate students, as well as representatives of academia and business. It is expected that IP-BAS will be in demand by industry representatives not only to provide analysis, but also to solve their technological problems. In addition opportunities for new cooperation and joint projects initiatives are also expected. The involvement of Branch Association Polymers in the project implementation (project management and communication activities) will contribute beyond the project life to reaching out targeted audience. It is expected an increase of the level of collaboration with the industrial sector, which, in turn, would ultimately enhance the innovation activities at IP-BAS. The acquired awareness of Intellectual Property Rights will facilitate the commercialization of the research results.
The project outcomes will have considerable impact on creation of better and more effective materials, processes, services, and technologies with the prospect that the most competitive of them to be implemented by the industry and reach the market. With regard to the key role of polymer materials for driving technology progress in many sectors such as pharmacy and medicine, electronics, energy storage, environment protection, etc., the improved research capacity of IP-BAS is expected to contribute to the national and regional economic growth. The increased IP-BAS research potential may impact the quality of life viewing the wide applications of polymers and polymer materials in everyday life. Those also provide the young researchers with better opportunities to build scientific careers at home thus generating young specialists with solid competencies, knowledge, and expertise able to strongly contribute to the regional economic and social development.
The project has had an employment effect that can be estimated on 27 Full Time Equivalent (FTE = one person working fulltime for a year) jobs. Besides the IP-BAS staff involved in the implementation of the project (experienced and early stage researchers, project assistants) ten experiences researchers, two experienced technicians, an IPI manager and expert were recruited specifically for the project. In total 44 persons (26 women and 18 men) were directly involved in organization and implementation of the project tasks.
The POLINNOVA project was not focused on gender equality aspects, as well as there was no gender dimension associated with the research/technical content of the project. The project management, however, was sensitive to the gender issues in the course of the project making efforts to keep as much as

possible the gender balance in the workforce. Women and men were equally welcome in the project team. The scientific achievements and experience of the involved persons were a matter of utmost importance in the project. The whole staff at the Institute, including the recruited experienced researchers and technicians, IPI manager and expert, has been afforded equal opportunities for career development, transparent procedures and working conditions being coherent with the principles in the European Charter for Researchers.

Educational and training activities on various levels, exchange of knowledge and know-how and enhancement of qualification were priorities of the POLINNOVA project. There were different training courses (on IPR issues, Horizon 2020 and project writing and management, equipment exploitation) and workshops (on research and innovations in the field of polymer materials, innovation strategy) that were organized within the planned activities and reported in Deliverables: D3.2 D3.3 D4.2 D4.3 D4.4 and D4.5. These events were designed for experienced researchers, early stage researchers as well as PhD students and technicians. In addition, demonstrations of the capacities of equipment acquired on the project and areas of potential application of the analytical methods used, as well as educational lectures were organized within the Open Doors Days addressed to students, school pupils, business, general public and related academia (Deliverable D5.8).

The impact of the POLINNOVA project is strengthened due to the synergies of science and education activities. The scientists of IP-BAS produced ten books and books chapters (listed in Deliverable 7.4) that can be used by students (bachelors, masters and PhDs). In parallel to the POLINNOVA project the Institute was implementing a project aimed at supporting the career development of PhD students and young researchers. A core activity in that project was the organization of three educational lecture courses on current topics in polymer science: Development and application of polymer nanomaterials, Polymers in medicine and New polymer materials for ecological purposes. Experienced researchers from IP-BAS are leading lecture courses at the Doctorate school at the Academy, as well as in Sofia University. The synergies of science and education are an efficient tool contributing to sustainable development of the human resources.

Wide usage of polymer materials and their importance for the development of different industrial and technological sectors imply broad range of studies and joint investigations with researchers working in associated disciplines. It is seen from the research and innovation outcomes produced by the Institute they have been obtained as a result from collaborative work with scientists from different fields such as:

• Health sciences (gene/drug delivery carriers; materials for medical/pharmaceutical applications, hygiene, etc.)

• Engineering sciences (materials engineering; cells for energy storage and conversion; food packaging; etc.)

• Biotechnology – polymer membranes and supports/hydrogels application in biotechnological processes

• Environmental sciences (alternative energy sources; waste water management; usage of renewable resources, etc.)

Increasing the visibility of the Institute and promoting the dialogue between scientists and civil society, including business circles, policy makers and other stakeholders were among the tasks and, correspondingly, the activities of the POLINNOVA project. Interaction with different societal groups (representatives of branch organizations, clusters, local authorities, students, innovators, etc.) was established in the course of the dissemination and communication activities. The Management group and staff involved in these activities did not engage a professional mediator or communication company. The Management group of the project followed the planned activities and used the Institute’s human resources

including the recruited IPI manager and expert, as well as the project assistants in the preparation of the communication materials. The Bulgarian Academy of Sciences possesses a Public Relations office which the Institute has consulted with in some cases of announcements and media coverage.
Examples of engaging societal groups in the project activities are as follows:
• During the International Plovdiv Fair, October 2013, (Bulgaria) IP-BAS and Branch Association Polymers initiated a meeting with members of the Association and representatives of the Bulgarian polymer industry. Scientists of the Institute presented the research activities and the equipment and initiated a dialogue about the closer interactions and activities with the industry and policy makers concerning the national innovation framework.
• The research and innovation potential of the Institute of Polymers for technological development and competitiveness and the POLINNOVA project support was communicated at an event organized by the Srednogorie Copper Industrial Cluster and the support of Aurubis AG, Siemens, Association of Busness Clusters, etc. The event was attended by representatives of the Ministry of Economics, Innovation Fund of Bulgaria, Siemens, Association of Busness Clusters and others;
• The director of IP-BAS Assoc. Prof. Dr. Neli Koseva took part and delivered a talk at a 2-days Conference organized by the Regional Academic Center in Sliven on 24-25 March 2014. Prof. Kostadinov participated in a meeting at the Regional Academic Center of Gabrovo dedicated to the challenges in front of the industry based on knowledge. In the discussions representatives of local authorities, education and business took part;
• In the workshop “Bulgaria 2020 Innovation Strategy – Challenges for Academia and Industry” that took place on 7-th November 2015 and was attended by 68 participants. Besides the scientists from the IP-BAS and colleagues from universities and research organisations, at the workshop actively participated Mrs. Jordanka Fandakova – Mayor of Sofia municipality, members of the Expert Council for Science, Technologies and Innovations associated to the Sofia municipality, Mr. Stefan Uzunov – state expert in the “Innovations and Entrepreneurship” Department of the Ministry of Economy and Energy, Mrs Karina Angelieva – a representative of the Permanent Representation (PR) of the Republic of Bulgaria to the EU; Mr. Nikolay Minkov – Executive Director and Member of the Executive Board of the Srednogorie Cluster, Eng. Valeri Nazarov - Director of R&D Department and member of the Management of Biovet (Joint Stock Company), Mr Georgi Krastev –Manager of Chemical Products Ltd., Yambol, acad. Alexander Petrov – Chair of the Consultative Scientific Council “Nanosciences, New Materials and Technologies”, representative of the Branch Association Polymers, Assoc. Prof. Georgi Rajchevski - Joint Innovation Centre, the National Union of Students (Deliverable D4.5 provides more details about the workshop).
• MS Halacheva, recruited on the project IP expert, delivered a presentation and participated in the discussion at the MSCA event called “MSCA Bridging Business and Research” on April 22, 2015, organized by the European Commission in co-operation with the Ministry of science and education.
• The recruited IPI manager took part at the workshop on “Patents, Intellectual Property, Technology Transfer”, organized by the Sofia Tech Park (May, 20 2014, Sofia).

The Strategic Plan for Intellectual Properties Development and Building the Innovation Capacity of IP-BAS as generated output of the project was designed to facilitate the accomplishment of research ideas and delivery of innovative outcomes. It is a strategic document composed of three separate documents that can be used by policy makers or other organisations (including academia) as far as they develop internal rules and measures for promoting innovation activities and protection/exploitation of IP. Another document resulted from the POLINNOVA project is the Ex-post Evaluation Report that was prepared upon the

project completion by a team of three external independent experts appointed by the European Commission. The report includes estimation of the implementation of the POLINNOVA project and its impact on the performance of the Institute of Polymers, a forward-looking section with an updated SWOT analysis of the foreseeing the Institute's activities in the ERA context. The report can be used by policy actors in the field of Science and Education as an analytical basis and expert opinion in deriving future measures and actions.
The project activities did not undergo an Ethic Review. The project did not include research on humans, human embryos and animals. The activities did not involve processing of genetic information or personal data, as well as the use of any local genetic, animal, plant, etc. resources. All activities carried out under POLINNOVA project and the results from them have neither direct military use nor potential for terrorist abuse.
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Related documents

final1-public.pdf

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