NMP-CT-2003-505567

BIOCELSOL

Biotechnological Process for Manufacturing Cellulosic Products with Added Value

Instrument:	Specific Targeted Research Project (STREP)
Thematic Priority:	Nanotechnology and nanosciences, knowledge based multifunctional materials, new production processes and devices (NMP)

FINAL REPORTS

Part of D43, Public

Publishable final activity report including publishable project results, and D29 Summary report of Interim progress reports (PU)

Period covered:	from 1.3.2004 to 28.2.2007 (project months 1–36)
Start date of project:	1st March 2004
Duration:	36 months

Project co-ordinator organisation name: Tamlink Ltd

Project co-ordinator name: Sirkku Hoikkala

Date of preparation:	12th April 2007
Revision:	[final version]

Introduction

A novel biotechnology-based method for converting cellulose into fibres, films, casings, beads and sponges was studied and further developed during the Biocelsol project (1.3.2004 – 28.2.2007). In the method the dissolving grade pulp is modified to an alkali soluble form by treating it with enzymes. The treated pulp is thereafter dissolved and the cellulose solution regenerated into desired shapes. No hazardous and toxic carbon disulphide (CS_2), which is used in the viscose method, is needed and thus no emissions to the air are liberated, contrary to the viscose process. The methodology used included the optimisation of 1) enzymatic action on cellulose, 2) dissolution technique of treated cellulose and 3) regeneration of alkaline cellulose solution.

The research work was carried out in laboratory scale in five groups, which focused on the pulp treatments (WP1), dissolution of treated pulp (WP2), development of fibre spinning process (WP3), development of film and fibrous casings production processes (WP4) and development of beads and sponges production processes (WP5). The selected processes were also demonstrated in high-laboratory, pilot or industrial scales (WP7). The innovation related issues such as IPR, dissemination and exploitation as well as the management activities were carried out in two separate workpackages (WP6 and WP8).

The Biocelsol consortium consists of eight research organisations and universities and eight industrial participants, from which four represent small or medium size enterprises (SMEs). Table 1.

Table 1. List of Biocelsol participants.

Contractor	Contribution	Country
Co-ordinator: Sirkku Hoikkala Tamlink Innovation-Research-Development Ltd (Tamlink) e-mail: sirkku.hoikkala@tamlink.fi fax: +358 3 316 5123 www.tamlink.fi	WP8 Management WP6 Innovation related activities (Leader)	Finland
Scientific co-ordinator: Marianna Vehviläinen Tampere University of Technology (TUT) e-mail: marianna.vehvilainen@tut.fi fax: +358 3 3115 2955 www.tut.fi/kmt/en	WP1 Raw Materials WP3 Fibres (Leader) WP6 Innovation related activities	Finland
IFP Research AB (IFPR) www.ifpsicomp.se	WP3 Fibres WP6 Innovation related activities WP7 Demonstrations (Leader)	Sweden
Institute of Biopolymers and Chemical Fibres (IBWCh) www.ibwch.lodz.pl	WP2 Solutions (Leader) WP3 Fibres WP4 Films (Leader) WP6 Innovation related activities WP7 Demonstrations	Poland
VTT Technical Research Centre of Finland (VTT) www.vtt.fi	WP1 Raw Materials (Leader) WP6 Innovation related activities WP7 Demonstrations	Finland
Åbo Akademi University (AAU) www.abo.fi/fak/ktf/tra	WP5 Sponges & Beads (Leader) WP6 Innovation related activities	Finland
University of Potsdam (UP) www.uni-potsdam.de	WP1 Raw Materials	Germany
Slovak University of Technology (STU) www.stuba.sk	WP1 Raw Materials WP2 Solutions WP4 Films	Slovakia
University of Bielsko-Biala (UBB) www.ath.bielsko.pl	WP1 Raw Materials WP2 Solutions WP3 Fibres WP4 Films WP5 Sponges & Beads	Poland
Domsjö Fabriker Ab (DF) www.domsjoe.com	WP1 Raw Materials	Sweden
Vivoxid Ltd (Vivoxid) www.vivoxid.com	WP5 Sponges & Beads WP6 Innovation related activities	Finland
Oy Visko Ab (Visko) www.visko.net	WP2 Solutions WP4 Films WP6 Innovation related activities WP7 Demonstrations	Finland
Gumitex Poli-Farm Ltd (Gumitex) www.gumitex.pl	WP4 Films WP6 Innovation related activities WP7 Demonstrations	Poland
Suominen Nonwovens Ltd (Suominen) www.suominen.fi	WP3 Fibres WP6 Innovation related activities WP7 Demonstrations	Finland
Spolsin, spol. s r.o. (Spolsin) www.spolsin.cz	WP3 Fibres WP6 Innovation related activities WP7 Demonstrations	Czech Republic
Ahlstrom Research and Services (ARS) www.ahlstrom.com	WP1 Raw Materials WP3 Fibres WP4 Films WP6 Innovation related activities WP7 Demonstrations	France

Work performed and results achieved

The objectives of the Biocelsol project were to understand the enzymatic action on the cellulose and its impact on the structure and processability of cellulose, to develop viable processes for fibres, films, casings, beads and sponges as well as to demonstrate them.

The effect of combined chemical, mechanical and enzymatic treatments to produce cellulose with high alkaline solubility and acceptable viscosity was studied (VTT, TUT, UP, STU, UBB, DF, ARS). The pulp characteristics such as alkaline solubility, viscosity, DP, crystallinity, porosity, fibre characteristic and WRV were analysed. Large amounts of analytical data of the differently pre-treated pulps and the effects of different treatment steps and combinations were gathered. Knowledge of the factors affecting cellulose properties and enzymatic treatments was obtained. As a result of different pre-treatments and enzymatic treatment with experimental or commercial enzymes, cellulose with high solubility and good solution properties was prepared with low yield loss in the enzymatic treatment. Enzymatic treatment was scaled-up to 15 kg of treated pulp (DF, VTT, Visko).

The enzyme-treated pulp was dissolved and the effect of parameters such as cellulose concentration, NaOH content in solvent, total NaOH content of solution, zinc oxide content, as well as time and temperature of dissolution on solution properties was studied and optimised (IBWCh). The sample related parameters which was found to affect the solution properties were types of starting pulp and pretreatment, as well as type and dosage of the enzyme used. The effect of all the factors on the solution properties were investigated by analysing the falling ball viscosity, dynamic viscosity, filterability and amount of insoluble particles of the solution.

The highest cellulose content with acceptable viscosity was 6.5%. The amount of zinc oxide in the solution was 0.84 – 1.3 wt% and the total NaOH content 7.8 wt%, the alkali solubility of the cellulose was higher than 99% and the alkali to cellulose ratio equal to 1.2.

Studies on the Biocelsol/viscose blend solutions were also carried out to optimise the composition ratio regarding the rheological properties (STU, Visko). The power law exponent was found as a key parameter characterising the processability of solutions and providing important information for fibres, films and other regenerated cellulose product formation.

The dissolution process was scaled up to 250 kg of solution (Visko).

The end product processes developed have different requirements for the cellulose solution. All the undissolved particles should be removed from the fibre spinning solution, whereas they are not that critical for the processability of films, fibrous casings, beads or sponges. The content of cellulose in each case should be as high as possible for economical reasons, however without increasing the falling ball viscosity too much.

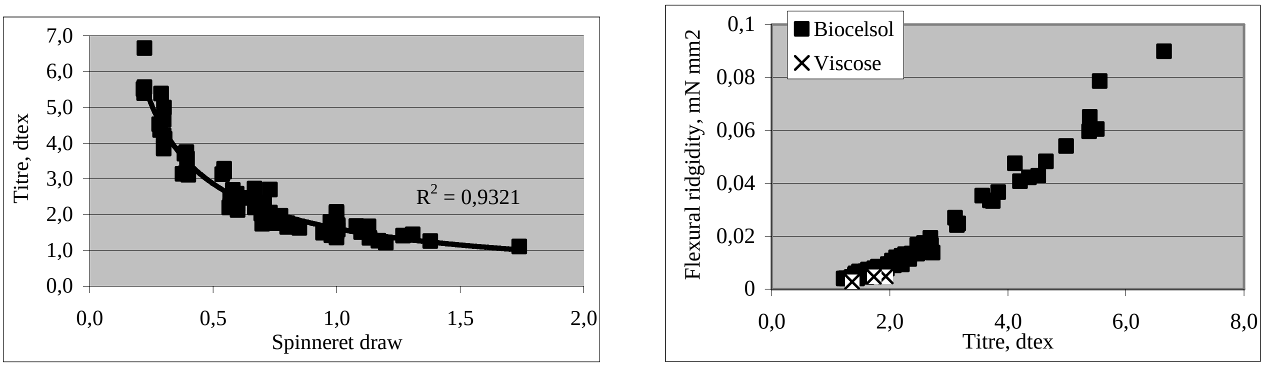
Fibres

Optimisation of the fibre wet spinning process was done at laboratory scale (TUT) and the production of fibres for application trials (up to 2 kg batches) at high-laboratory scale (IBWCh). Additionally, an electrospinning technique for producing cellulosic nanofibres from differently pretreated pulps dissolved in LiCl/DMAc was studied at laboratory scale (IFPR).

The parameters studied in wet spinning trials included falling ball viscosity, cellulose content, stability and additives of the spinning solution, composition of the coagulation bath, spinneret type, spinneret draw, coagulation distance, stretching ratio, spinning speed and type of fibre finishing. The effect of different parameters on the fibre properties was analysed by measuring the mechanical and absorption properties, crystallinity degree, size of crystallites, porosity by internal surface, orientation factor and molecular weight distributions of the fibres. Additionally, the surface and cross sections were studied by SEM images.

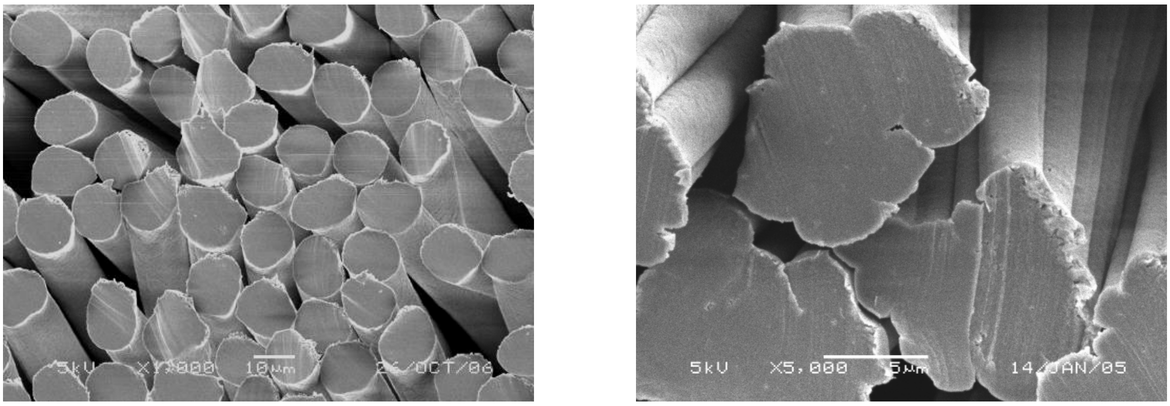
The parameters studied in electrospinning trials included pulp characteristics, dissolution procedure, viscosity of solution, surrounding environment, voltage and distance between the nozzle and the collector. The fibres obtained were studied by SEM.

In the wet spinning the spinneret draw was found to correlate with the fibre titre according to power equation (Figure 1a). This and the round cross section of the fibres (Figure 2 a) indicate that the fibre structure is solidified to some extent in the coagulation bath. However, firm cross links are not yet formed, since the fibres are able to be stretched up to 55% depending on the spinneret draw applied and the constitution of the spin bath used. The flexural rigidity of the Biocelsol fibres at the same titre is higher than of the viscose fibres. This is also explained by the round cross section of the Biocelsol fibres which makes them stiffer as compared to the viscose fibres. (Figure 1b).



a) b)

Figure 1. a) Relationship between spinneret draw applied during the spinning and the titre of the obtained fibres. b) Flexural rigidity of the Biocelsol and viscose fibres.

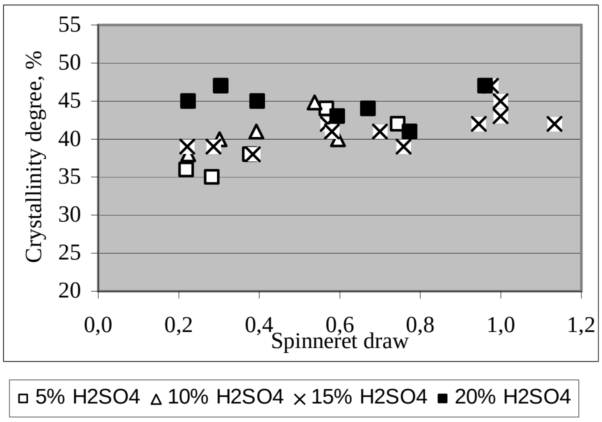


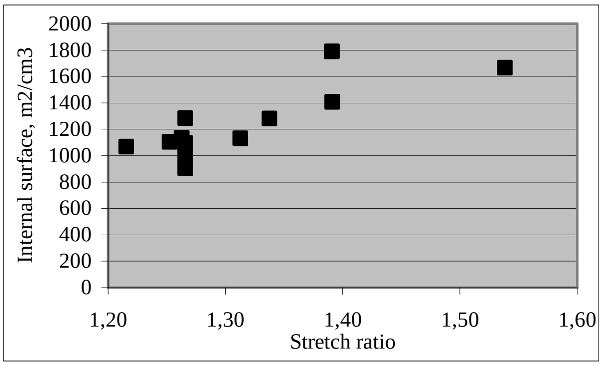
a) b)

Figure 2. Typical cross sections of a) Biocelsol fibres and b) viscose fibres. (Biocelsol fibres spun at TUT, the SEM images by UBB)

Crystallinity degree of the wet spun Biocelsol fibres ranges between 35 and 47 %, increasing slightly with increasing spinneret draw and increasing sulphuric acid concentration in the coagulation bath. However, the effect of acid concentration on crystallinity was more pronounced with spinneret draws lower than 0.5 (Figure 3a). Internal surface of the fibres varies in large range and was found to correlate positively with the stretch ratio (Figure 3b). The orientation factor of the Biocelsol fibres depends on the spinneret draw, stretch ratio and sulphuric acid concentration of the coagulation bath as seen in Figure 4a.

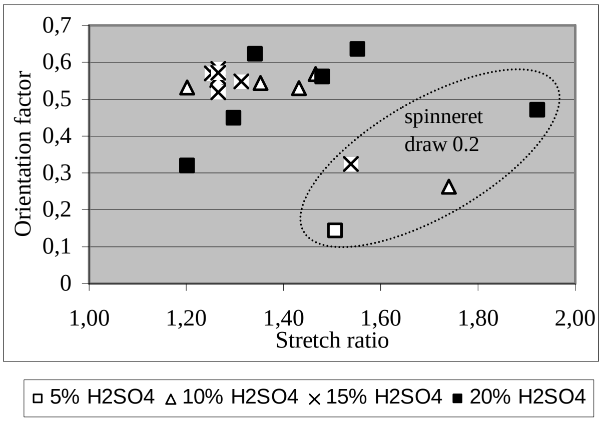
The absorption capacity of the wet spun Biocelsol fibres as measured by the swelling coefficient value (the wet sample is centrifuged for 80s at 3000g and the moisture measured) is 70% higher as compared to the reference nonwoven type viscose fibres. Figure 4b.

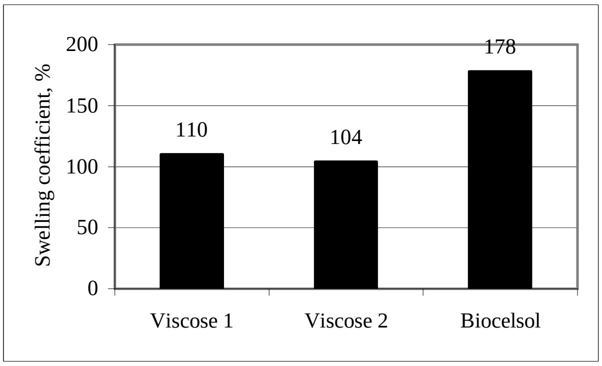




a) *b)*

Figure 3. a) Crystallinity degree of the Biocelsol fibres in the function of spinneret draw. b) Internal surface of the Biocelsol fibres in the function of stretch ratio.

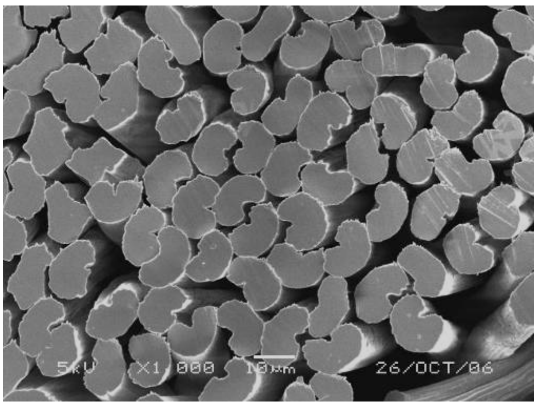


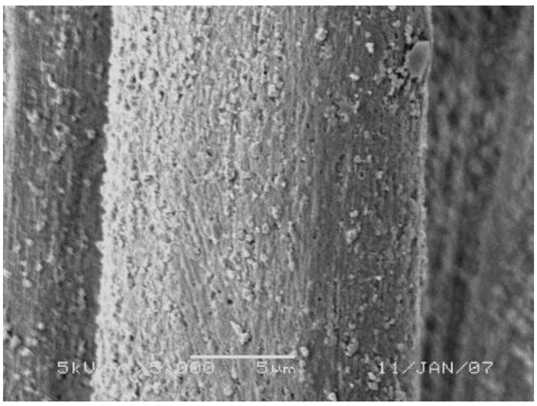


a) *b)*

Figure 4. a) Orientation factor of the Biocelsol fibres in the function of stretch ratio. b) Swelling coefficient values of nonwoven type viscose fibres and Biocelsol fibre.

The coagulation conditions determine largely the structure and appearance of the wet spun Biocelsol fibres . Thus, it was also possible to obtain fibres with bean-shaped cross section (Figure 5a) or spotted surface (Figure 5b) by altering the constitution of the coagulation media.

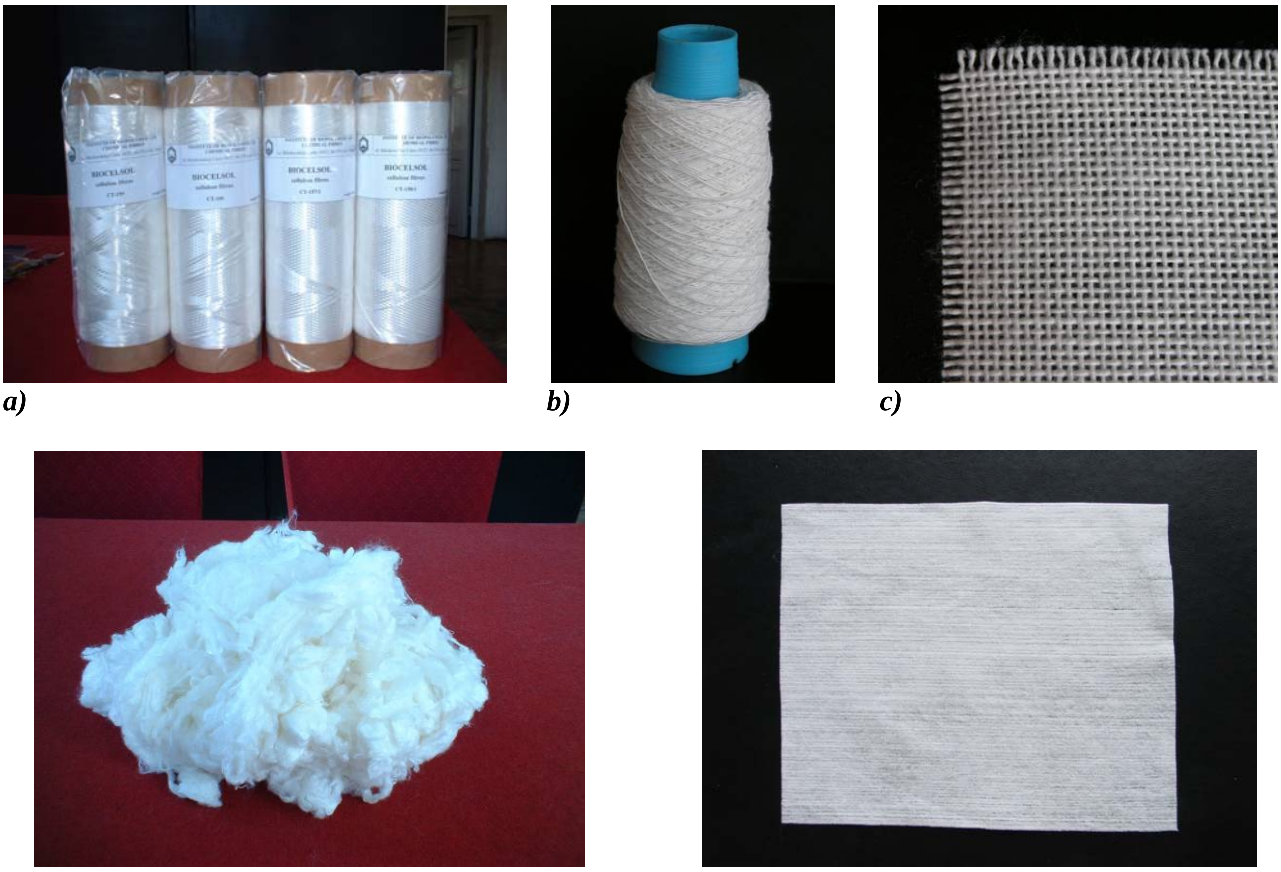




a) *b)*

Figure 5. a) Bean-shaped cross-section and b) spotted surface of the Biocelsol fibres. (Biocelsol fibres spun at TUT, the SEM images by UBB)

Mechanical properties of the fibres must be at certain level until they are of technical interest for further processes, and for the properties of the end products. The highest tenacity of the wet spun Biocelsol fibres obtained at laboratory scale was 1.8-1.9 cN/dtex with elongation of 14-19%. It turned out to be challenging to produce fibres with the same properties at high-laboratory scale. This was probably due to slightly different construction of the spinning line. Consequently, the fibres produced for application trials had lower mechanical strength than obtained at laboratory scale. In spite of that, yarn, knitted fabric, woven fabric and nonwoven sheets were successfully prepared from the Biocelsol fibres. Figure 6.



a) *b)* *c)*

d) *e)*

Figure 6. Biocelsol fibres and end products. a) Multifilament fibres (IBWCh), b) Sheath-core yarn (Spolsin), c) Fabric from sheath-core yarns (Spolsin), c) Staple fibres (IBWCh) and d)Hydroentangled nonwoven sheet from staple fibres (Suominen).

The production of nanofibres by electrospinning was demanding due to very narrow process window.However, preliminary fibers were obtained from several cellulose samples, whereof the steam-exploded pulp proved to be a very promising sample. A SEM image of the resulting electrospun fibres of steam exploded and enzymatically treated pulp (3% pulp in 6% LiCl:DMAc solution) is shown in Figure 7.

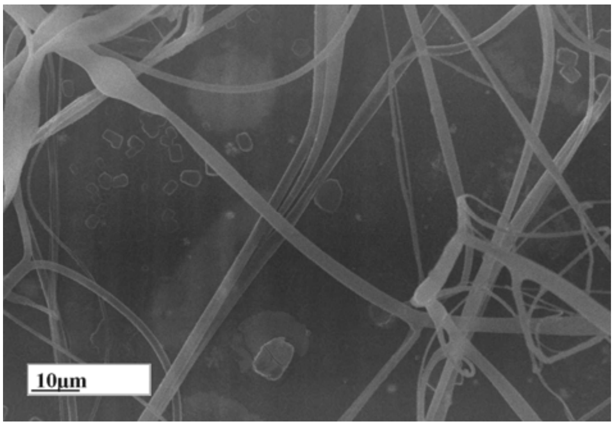


Figure 7. SEM image of electrospun fibres.

Films, impregnated webs and fibrous casings

Optimisation of the film production (IBWCh), web impregnation (ARS) and fibrous casings production (Visko) were done at laboratory scale. The film production was scaled up to high-laboratory scale, whereas web impregnation was demonstrated in pilot scale and fibrous casings production in industrial scale. Effects of the solution properties (polymer and zinc oxide content), coagulation bath composition, coagulation bath additives and finishing agents on the mechanical properties of the products were studied.

The high-laboratory method to produce Biocelsol film sheets of 50 cm x 50 cm was developed (Figure 8). The Biocelsol films obtained have tenacity higher than 100 MPa and elasticity of 20-30%. A larger amount (750 g) of film sheets were produced for packaging tests.

a)

b)

c)

Figure 8. Preparation of film sheets in IBWCh. a) Solution is spread on the glass plate, b) coagulated film is transferred from acidic bath to washing bath, and c) dry films ready for application trials.

Web impregnation trials focused on replacing the viscose solution, currently used for impregnating paper web, by the Biocelsol solution. The enzyme-treated pulp was dissolved, the solution obtained diluted and applied for impregnation (ARS). The alkaline concentration of Biocelsol solution turned out to be too high for the paper web, thus it deteriorated during the trial. Consequently, the web impregnated with Biocelsol solutions did not reach the properties obtained with the viscose solution.

The Biocelsol solution for fibrous casings production in industrial scale was prepared without zinc oxide (Visko). Thus, the cellulose concentration was lower and the viscosity higher than the optimal values, which caused low impregnation of the solution into the base paper. In spite of that, the casing run well on the line and about 10 m of casing was obtained. Figure 9.

a) *b)*

Figure 9. Industrial scale production of fibrous casings in Visko. a) Biocelsol casing (white) on the outer line in a fibrous casing machine. b) Dry Biocelsol casing.

<u>Beads and sponges</u>

Development of a coagulation technique for cellulosic beads and sponges from Biocelsol and Biocelsol/viscose blend solutions were done at laboratory scale (AAU, IFPR, Vivoxid). The apparatus for bead generation based on rotating atomizer was developed (AAU) and the process parameters optimised regarding size, shape, and surface chemistry of the beads. Tailoring of the bead properties made from Biocelsol solution was limited compared to the beads prepared from viscose solution. The maximum size of the Biocelsol beads was smaller, the size distribution much broader, and the shape more irregular than of the viscose beads. Some of the prepared bead types were suitable for excipient in tablet making. The obtained tablets were tested for their properties and the results show that they fulfil the pharmaceutical regulations. The purity and chemical properties of the beads should still be evaluated to make sure that the material is suitable for these tightly regulated purposes.

Additionally, an electro spraying technique to produce beads was studied (IFPR). As the aqueous Biocelsol solution does not solidify in the air, the sulphuric acid bath was used as a collector. The shape and size of beads were possible to control by cellulose concentration and the distance between the nozzle and the bath. The beads obtained were smaller than the ones from rotating atomizer and they tended to agglomerate when dried. Figure 10.

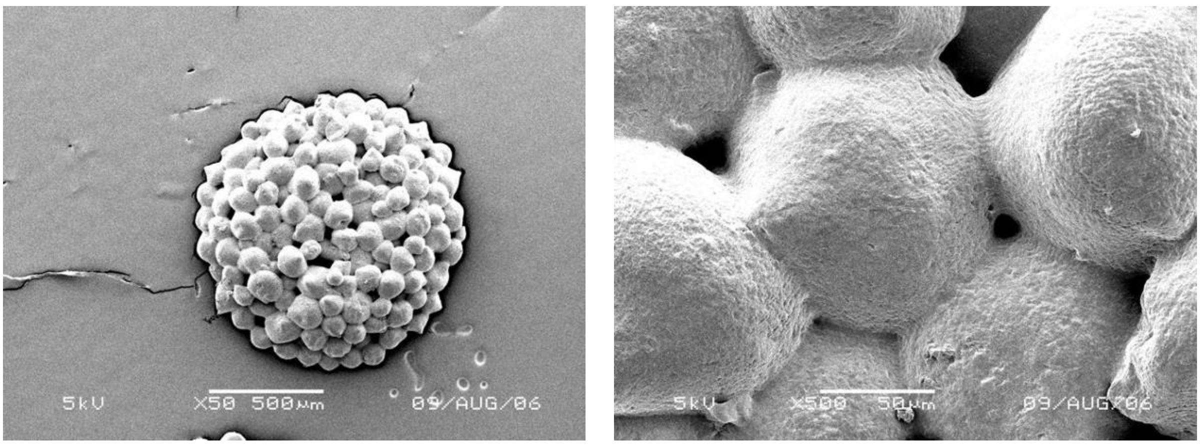


Figure 10. Agglomerate of dried electro sprayed beads.

Development of a sponge making procedure was carried out by optimising the process parameters known from the production of viscose sponges. It turned out that the Biocelsol sponge with adequate strength could not be prepared. Only by adding some supportive cotton fibres, it was possible to produce Biocelsol sponge, although the structure was not homogeneous due to uneven mixing technique. SEM image of the sponge prepared from the viscose solution is presented in Figure 11.

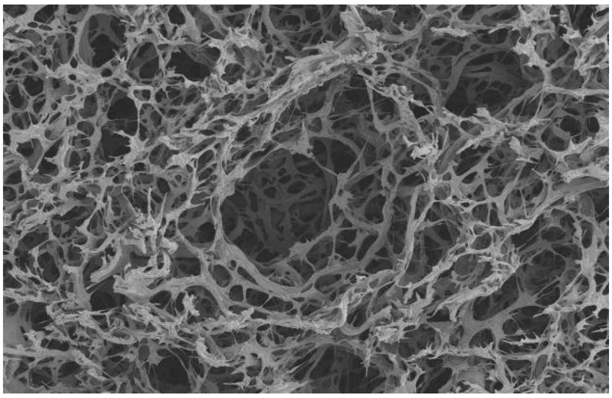


Figure 11. SEM image of a viscose sponge.

The Biocelsol/viscose blend solutions were also investigated. Beads could be made containing any ratio of viscose and Biocelsol. Sponges were also made from blends with different viscose to Biocelsol ratios. The structure of the resulted sponges became harder the more Biocelsol was in the blend. The properties of these sponges should be evaluated, since they might be preferable in some applications. Also the cleanliness of these sponges should be investigated.

The produced Biocelsol beads and sponges are expected to be biocompatible due to elimination of CS_2 as compared to the respective products from the viscose solution. Thus, they should be suitable for various pharmaceutical, medical, and clinical applications, for example tablet production and aerosol applications (beads), and wound healing (sponges).

<u>Feasibility studies</u>

The raw material, energy and labour costs of the Biocelsol and viscose fibre processes were attempted to compare. The raw material consumption of the Biocelsol process was estimated to be 7-8% higher than of the viscose process. The main reason for that is the higher alkali consumption of the Biocelsol process. The energy costs are somewhat difficult to compare, because relevant information from the viscose process is not available, and there is no pilot scale fibre process line for Biocelsol. The labour costs were estimated to be the same for the both processes, although the employees' comfort is considerable better in the Biocelsol process due to the elimination of carbon disulphide.

It should also be stressed that environmental taxes due to emissions from the use of carbon disulphide in the viscose process are not included, because they depend on the location of the factory. Costs related to the handling, storage, safety procedures and recovery of carbon disulphide are not either included, and thus should turn the figures more favourable for the Biocelsol. However, the Biocelsol process should be further optimised to decrease the alkali consumption and improve the end product properties, as well as the pilot plant experiments should also be carried out to evaluate the final feasibility of the Biocelsol process.

Conclusions

Procedure to prepare cellulose with high solubility and good solution properties in aqueous alkali was developed with low yield loss in the enzymatic treatment. The procedure includes pretreatment of dissolving type pulp and enzymatic treatment with commercial or experimental enzymes. The treated cellulose is dissolved to obtain solution containing 4-6.5% cellulose, 0-1.3% zinc oxide and 7.8% sodium hydroxide depending on the application. The lowest alkali to cellulose ratio obtained was 1.2, which is higher than targeted level. Due to economy of the process it is essential to further decrease the ratio, thus more studies are needed after this project. Scaling up the best cellulose pretreatment method is also a matter of further studies.

Processes for fibres, films, impregnated webs, fibrous casings, beads and sponges were developed utilising the enzyme-treated pulp without any need of carbon disulphide. Targeted tenacity for the fibres at the beginning of the project was 2.7 cN/dtex and for the films 50 MPa. The fibre tenacity was not achieved, but the highest tenacity obtained at laboratory scale remained at 1.9 cN/dtex. Instead, the targeted film tenacity was achieved and surpassed clearly. The fibres produced for application trials had even lower tenacity than 1.9 cN/dtex, in spite of that yarns, fabric and nonwovens were produced without major problems.

Trials to impregnate paper web with Biocelsol solution did not succeed because the web did not stand the high alkalinity of the Biocelsol solution. Instead, the industrial scale trial to produce fibrous casings by coating the viscose bonded paper web with Biocelsol solution went surprisingly well, even though the solution parameters were not yet optimal. Beads were successfully prepared from Biocelsol solution and their characteristics turned out to be different and probably better than of the beads made from the viscose solution. Instead, the sponge production from the Biocelsol solution was more difficult than expected and needs more studies to obtain desired results.

The research and development gaps of the Biocelsol project were identified to be the scaling up of the best pretreatment method, the high alkali to cellulose ratio of the solution, the low fibre tenacity and the lack of the pilot scale production of fibres for application trials. All these are considered and will be the topics of the next projects.

Impact of the project

Huge amount of data about the cellulose treatments and application studies was gathered during the project. Major part of the data has not been published yet, but will be in the near future. The dissemination of the results will increase the activities in the cellulose research sector dealing with enzymatic treatments and utilisation of the enzyme-treated pulp in existing and in new applications.

The direct impact of the Biocelsol project on the current industry fields which produce dissolving type pulp, use the viscose technology for fibres, films or fibrous casings or produce different end product from viscose fibres, is small. However, if the research and development gaps identified are fulfilled during the following projects, the impact will be multiplied.

With the successful scaling up of the best pretreatment method there will be sufficient amount of treated pulp for pilot scale fibre, film and fibrous casings trials, which in turn will ensure a proper process optimisation and provide more information about the feasibility of the processes.

With favourable figures the impact for example on the current viscose fibre industry might be drastic. The European viscose fibre producers have been forced to make high investments because the use of carbon disulphide (recovery, circulation, waste waters, safety, handling and storage), which restricts the new investments in favour of the other process. Due to that the companies benefiting from the Biocelsol technology might be the others than the current enterprises in the field and thus the competition in the fibre markets might be increased.

The industry currently using the viscose fibres for hygiene end products will benefit in the form of new type of cellulose fibre, which has higher swelling capacity as compared to the viscose fibre and is odourless due to total absence of sulphur impurities in the fibre. This will improve the end product properties and most probably increase their share in the markets.

Additionally, the industry producing dissolving type pulp for the viscose based processes will have a new type of product in their selection, which should increase the turn over of the companies.

Plan for using and disseminating the knowledge

Part 1 Project and results overview

PROJECT SUMMARY

EC PROGRAMME:	FP6-NMP
PROJECT TITLE:	Biotechnological Process for Manufacturing Cellulosic Products with Added Value
PROJECT ACRONYM:	BIOCELSOL
CONTRACT NUMBER :	NMP-CT-2003-505567
PROJECT WEB SITE (if any) :	http://www.tut.fi/units/ms/teva/biocelsol/index.htm
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EC Directorate General	RTD G2

OVERVIEW OF MAIN PROJECT RESULTS

No	Self-descriptive title of the result	Category A, B or C*	Partner(s) owning the result(s) (referring in particular to specific patents, copyrights, etc.) & involved in their further use
1	Wet spun cellulosic fibres for nonwoven applications	A	Tampere University of Technology
2	Preliminary nanofibres from electrospinning treated cellulose dissolved in lithium chloride/Dimethylacrylamide solution	A	IFP Research AB
3	Forming fibres (including antimicrobial fibres) from enzyme-treated cellulose pulp	A, B	Institute of Biopolymers and Chemical Fibres
4	Forming films from enzyme-treated cellulose pulp	A, B	Institute of Biopolymers and Chemical Fibres
5	Apparatus and method for cellulose bead production and the bead itself	A	Aabo Akademi University
6	Method for evaluation of processability of Biocelsol alkali solution and blend Biocelsol/xanthate cellulose alkali solutions	A	Slovak University of Technology in Bratislava
7	Regenerated blend cellulose films based on Biocelsol/xanthate cellulose blend alkali solutions	A	Slovak University of Technology in Bratislava

* A: results usable outside the consortium / B: results usable within the consortium / C: non usable results

Part 2 Description of each result

1	WET SPUN CELLULOSIC FIBRES FOR NONWOVEN APPLICATIONS

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URL	
Specific Result URL	

SUMMARY

The alkaline cellulose solution is prepared by dissolving enzyme-treated pulp into aqueous sodium zincate solution without sulphurisation stage. Cellulosic fibres are spun from the alkaline cellulose solution by wet spinning method similarly as the viscose fibres. Neither carbon disulphide nor hydrogen sulphide is released during the spinning. The spinning parameters used are selected to obtain fibres with density of crimps between 2.5-4 crimps/cm, degree of crimps around 30-45%, tenacity of fibres at least 1.5 cN/dtex and elongation 15-20%. The obtained fibres are washed, finished with commercial nonwoven finishing agent and dried.

The fibres are applied to nonwoven products by hydroentanglement process. The nonwovens can be applied to wound dressings (annual consumption 30-50 tons), surgical drapes (annual consumption 5400-7200 tons) and baby-wipe products (annual consumption 140000 – 210000 tons).

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors codes	82	102	498	612	

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	x
Prototype/demonstrator available for testing	
Results of demonstration trials available	
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	
Patent granted	(x)
Patent search carried out	
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	x
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	x
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	17				

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	
LIC	Licence agreement	x	**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement	x	**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	
JV	Joint venture		**CONS**	Available for consultancy	
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

We can offer know-how of this process starting from the pulp treatments and ending to the fibre finishing. We also have facilities doing laboratory scale trials including the pulp treatment, dissolution, spinning and fibre finishing.
The possible markets for the product are huge, annual consumption of fibres being around 200 000 tons.

PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE

The external partner is needed to take responsibility for large scale trials in order to obtain sufficient amount of fibres for application trials.

2	**PRELIMINARY NANOFIBRES FROM ELECTROSPINNING TREATED CELLULOSE DISSOLVED IN LITHIUM CHLORIDE/ DIMETHYLACETAMIDE**

CONTACT PERSON FOR THIS RESULT

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Specific Result URL	IFP Research AB

SUMMARY

Electrospinning of preliminary nanofibers based on electrospinning of treated cellulose dissolved in lithium chloride/Dimethylacetamide solution. Since only preliminary fibers were reached, the potential to use the material in suitable, targeted applications is very low.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors	416	498	612	682	

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	x
Prototype/demonstrator available for testing	
Results of demonstration trials available	
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	
Patent granted	

Patent search carried out	
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	17				

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	
LIC	Licence agreement		**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement		**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	
JV	Joint venture		**CONS**	Available for consultancy	
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

Since only preliminary fibers were reached, the potential to use the material in suitable, targeted applications is very low. More R&D is necessary to find out the mechanisms ruling for electrospinning of the system and to be able to produce on large scale.

3	FORMING FIBRES (INCLUDING ANTIMICROBIAL FIBRES) FROM ENZYME-TREATED CELLULOSE PULP

CONTACT PERSON FOR THIS RESULT

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Specific Result URL	

SUMMARY

A new environment-friendly technology to produce cellulose fibres has been developed. The method is based on enzyme-treated cellulose pulp. Such pulp is distinguished by its solubility in aqueous alkalis enabling further processing such as wet-spinning. The process is designed to replace the viscose method, and may be implemented in existing viscose plant without major capital investment. Enzyme-treated cellulose is characterised by an average polymerisation degree of 350, and dissolves readily in aqueous sodium hydroxide with the dissolution degree amounting to 99%. The material is suitable for the preparation of alkaline solutions containing up to 6.5 wt% of cellulose at a total alkalinity of 7.9%. Such solution is featured by a corrected clogging value (Kw*) below 200, and as low as 0.5% content of insoluble particles, which is a precondition for the forming of cellulose fibres. Spinning trials with the alkaline solutions of the enzyme-treated cellulose confirmed the possibility of preparing fibres with tenacity in the range of 18-19 cN/tex, elongation in the range of 14 to 17% and Young modulus 22-50 cN/tex. Due to application of special finishing (after treatment) using bioactive agent it is possible to obtain fibres characterised by antimicrobial properties.
Obtained cellulose fibres are useful for further processing into technical products such as knitted / woven material, non-wovens or anti-microbial paper.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors	60	213	509	498	

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	x
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	
Prototype/demonstrator available for testing	

Results of demonstration trials available	x
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	x
Patent granted	
Patent search carried out	
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	x
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	17				

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	
LIC	Licence agreement	x	**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement		**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	x
JV	Joint venture		**CON**	Available for consultancy	x
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

A new technology for the manufacture of cellulose fibres based on enzyme-treated cellulose pulp has been elaborated. The technology provides the possibility to reduce emissions of toxic gases arising in viscose-process. New - generation of cellulose fibres produced from enzyme-treated pulp are characterised by properties comparable with standard viscose fibres. For that reason the cellulose fibres could replace viscose fibres in many applications. At the present stage, the fibres could be used as multifilament and spun yarns as well as in blend with other fibres in weaving and knitting. Thanks to high water absorbency, the fibres could be an ideal material for use in absorbent hygienic products and household materials.
A minor modification of the new technology enables the manufacture of fibres characterised by antimicrobial properties, useful in hygienic and medical devices.

PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE

The final product in a form of multifilament or staple cellulose fibres can be attractive for SME's which presently use viscose fibres. Cellulose fibres could replace viscose fibres. The products can be addressed to interior, technical, industrial textiles, hygiene products.
EDANA - the International Association Serving the Nonwovens and Related Industries is interested in the application of cellulose fibres for nonwovens production.

4	FORMING FILMS FROM ENZYME-TREATED CELLULOSE PULP

CONTACT PERSON FOR THIS RESULT

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Specific Result URL	

SUMMARY

A new environment-friendly technology to produce cellulose films and food casings has been developed. In this technology, the cellulose pulp is first treated with selected enzymes. Such treatment provides for the possibility of direct dissolution of cellulose in aqueous alkalies. Once dissolved e.g. in sodium hydroxide, the cellulose can be easily formed by coagulation with sulphuric acid into film and casings characterised by tenacity in the range of 100 -110 MPa and elongation up to 30%. Another possible use is in impregnation of paper with the alkaline cellulose solution.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors	60	234			

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	x
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	
Prototype/demonstrator available for testing	
Results of demonstration trials available	x
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	
Patent granted	
Patent search carried out	

Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	x
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	21				

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	
LIC	Licence agreement		**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement		**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	x
JV	Joint venture		**CON**	Available for consultancy	x
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

A new technology for manufacture of cellulose films and food casings based on enzyme-treated cellulose pulp has been elaborated. The technology provides the possibility to reduce emissions of toxic gases arising in the viscose-process. The new - generation of cellulose products from enzyme-treated pulp is characterised by properties comparable with standard viscose film. Film and food casings based on enzyme-treated cellulose solutions provide the chance to substitute other types of cellulosic films and casings such as cellophane.

PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE

Cellophane food casings are used in food packaging for many years. Presently there is a growing interest in the application of cellophane instead of plastics such as polypropylene and polyethylene. Biocelsol films and casings are thin and transparent material may be considered as substitutes for cellophane.
Talks have been begun with the world leader in film manufacture - Innovia Films, GB, concerning the possible use of Biocelsol technology.

5	APPARATUS AND METHOD FOR CELLULOSE BEAD PRODUCTION AND THE BEAD ITSELF

CONTACT PERSON FOR THIS RESULT

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SUMMARY

The result is apparatus and process for making of cellulose beads from viscose, Biocelsol or other cellulose solutions, or blends of them.
Cellulose particles (beads) prepared with the method described in the patent application can be tailored or engineered according the requirements of different products. In that way, the application is not limited to biomedical or biotechnological areas, being suitable for a multitude of high-added value products. They can be used as excipient in tablet making, targeted drug delivery systems, removal of toxic compounds (e.g. heavy metals and organohalogens), different applications in cosmetics, carrier for aromas, antibacterial, and deodorizing components, functional composite materials, scanning probes with attached molecules, chromatographic columns and many other uses besides the listed here.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors	474	415	169	103	75

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	
Prototype/demonstrator available for testing	
Results of demonstration trials available	x
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	x
Patent granted	
Patent search carried out	x
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	24	73	33		

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	x
LIC	Licence agreement	x	**VC**	Venture capital/spin-off funding	x
MAN	Manufacturing agreement	x	**PPP**	Private-public partnership	x
MKT	Marketing agreement/Franchising	x	**INFO**	Information exchange	x
JV	Joint venture	x	**CON**	Available for consultancy	x
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

-further research and development
-available for consultancy

PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE

-financial support
-joint venture
-private-public partnership

6	**METHOD FOR EVALUATION OF PROCESSABILITY OF BIOCELSOL ALKALI SOLUTION AND BLEND CELLULOSE BIOCELSOL/XANTHATE CELLULOSE ALKALI SOLUTIONS**

CONTACT PERSON FOR THIS RESULT

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SUMMARY

The method for evaluation of processing of Biocelsol alkali solutions and Biocelsol/xanthate cellulose blend alkali solutions consist in evaluation of deviation from Newtonian behaviour of these solutions expressed by suitable parameters such as power low exponent n.

The standard procedure for preparation of Biocelsol and Biocelsol/viscose alkali (blend) solutions containing additives or without them can be used. Similarly, the standard methods and devices e.g. rotary viscosimeter for measurement and evaluation of power law exponent and viscosity of alkali solution can be used. Solutions prepared must be storied preferable at low temperature about 1-3°C. The preferable temperature of rheological measurements is 10-15°C. The following equations are used for evaluating the basic rheological parameters: viscosity η and deviation from Newtonian behaviour n of solutions:

$\eta = \tau / \gamma^{\cdot}$ (Newton law)

where η - dynamic viscosity, τ - shear stress and $\gamma^{\cdot}$ - shear rate

$\tau = k \cdot \gamma^{\cdot n}$ (Power law)

where k – coefficient, n – deviation from the Newtonian flow (Power law exponent).

On the basis of experiment results, it was found that the power law exponent n is key rheological parameter for characterisation of processing properties of Biocelsol SS and Biocelsol SS/viscose blend solutions. Critical value of power low exponent was evaluated for n=0.6. Above critical value of power low exponent n>0.6 the Biocelsol and Biocelsol/viscose alkali solutions have acceptable processability. The solutions with power low exponent under critical value n<0.6 became non-processable.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors code	498	102	612		

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	x
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	
Prototype/demonstrator available for testing	
Results of demonstration trials available	
Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	
Patent granted	
Patent search carried out	
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	x
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	17	21	24		

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	x
LIC	Licence agreement	x	**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement		**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	x
JV	Joint venture		**CON**	Available for consultancy	x
			Other	(please specify)	

7	REGENERATED BLEND CELLULOSE FILMS BASED ON BIOCELSOL/XANTHATE CELLULOSE BLEND ALKALI SOLUTIONS

CONTACT PERSON FOR THIS RESULT

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Specific Result URL	

SUMMARY

Regenerated blend cellulose films based on Biocelsol/xanthate cellulose blend alkali solutions are prepared by coagulation in acid bath containing mineral acid (H_2SO_4) and (salt Na_2SO_4). Films with acceptable tenacity (above 50MPa) are prepared from Biocelsol/xanthate cellulose blend alkali solutions with power low exponent above critical value (0.6). Content of Biocelsol solution in blend solution can be in extent of 0-100% preferable 0-30% and 70-100%.

Regenerated cellulose films were prepared in laboratory conditions using simple device consisting of the: basic metal plate from rustless steel with milled profile for glass plate, glass plate and metal plate slider from rustless steel with milled surface. Procedure and conditions of film preparation: The spinning solution in amount was placed on the glass plate situated and fixed on basic metal plate close to starting edge. The solution was spread using glass stick and metal slider to form layer with defined thickness. The glass plate was immersed in coagulation bath. Films were several times washed with water.

The films with tenacity above 50 MPa was obtained for all laboratory prepared sample within concentration of Biocelsol solution in blend solution with viscose up to 30 wt %. It also corresponds with the acceptable power law exponent of spinning solution.

SUBJECT DESCRIPTORS (using codes from Annex 2)

Subject descriptors	498	102	612		

CURRENT STAGE OF DEVELOPMENT

Scientific and/or Technical knowledge (Basic research)	x
Guidelines, methodologies, technical drawings	
Software code	
Experimental development stage (laboratory prototype)	
Prototype/demonstrator available for testing	
Results of demonstration trials available	

Other (please specify.):	

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	
Patent applied for	
Patent granted	
Patent search carried out	
Licence agreement(s) reached	
Partnership / other contractual agreement(s)	
Exclusive rights	
Registered design	
Trademark applications	
Copyrights registered	
Secret know-how	x
Other - please specify:	

MARKET APPLICATION SECTORS (using the NACE classification from Annex 3)

Market application sectors	17	21	24		

COLLABORATIONS SOUGHT

R&D	Further research or development	x	**FIN**	Financial support	x
LIC	Licence agreement	x	**VC**	Venture capital/spin-off funding	
MAN	Manufacturing agreement		**PPP**	Private-public partnership	
MKT	Marketing agreement/Franchising		**INFO**	Information exchange	x
JV	Joint venture		**CON**	Available for consultancy	x
			Other	(please specify)	

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

New experimental results regarding the improvement of dissolving of enzyme-treated cellulose and properties of Biocelsol/xanthate cellulose alkali solutions would be useful for achievement of the technological stabile production of regenerated cellulose products using sulphur free technology.

The more experimental results are needed and cooperation in basic and applied research for more general conclusions leading to licence agreement concerning the blend films based on Biocelsol/xanthate cellulose blend solutions.

Biocelsol-project is partly financed by the Sixth Framework Programme of European Commission; more information is available at http://www.tut.fi/units/ms/teva/biocelsol/index.htm.

ANNEX 1 : FP6 EC programmes

FP6-AEROSPACE
FP6-CITIZENS
FP6-COORDINATION
FP6-EURATOM-FISSION
FP6-EURATOM-FUSION
FP6-EURATOM-JRC
FP6-EURATOM-NUCHORIZ
FP6-EURATOM-NUCTECH
FP6-EURATOM-NUWASTE
FP6-EURATOM-RADPROT
FP6-FOOD
FP6-INCO
FP6-INFRASTRUCTURES
FP6-INNOVATION
FP6-IST
FP6-JRC
FP6-LIFESCIHEALTH
FP6-MOBILITY
FP6-NEST
FP6-NMP
FP6-POLICIES
FP6-SME
FP6-SOCIETY
FP6-SUPPORT
FP6-SUSTDEV

ANNEX 2: SUBJECT DESCRIPTOR CODES

1	ACARIANS	42	APPLIED MATHEMATICS
2	ACCIDENTOLOGY	43	APPLIED PHYSICS
3	ACCOUNTING	44	AQUACULTURE, AQUACULTURE TECHNOLOGY
4	ACOUSTICS	45	ARCHIVISTICS/DOCUMENTATION/ TECHNICAL DOCUMENTATION
5	ADMINISTRATIVE SCIENCES, ADMINISTRATION	46	ARCTIC ENVIRONMENT
6	ADULT EDUCATION, PERMANENT EDUCATION	47	ARTIFICIAL INTELLIGENCE
7	AERONAUTICS	48	ARTS
8	AGEING	49	ASSESSMENT AND MANAGEMENT OF LIVING RESOURCES
9	AGRICULTURAL CHEMISTRY	50	ASTRONOMY
10	AGRICULTURAL ECONOMICS	51	ASTROPHYSICS/PLANETARY GEOLOGY
11	AGRICULTURAL ENGINEERING/TECHNOLOGY	52	ATOMIC AND MOLECULAR PHYSICS
12	AGRICULTURAL MARKETING/TRADE	53	AUDIOVISUAL COMMUNICATION
13	AGRICULTURAL PRODUCTION SYSTEMS	54	AUTOMATION, ROBOTIC CONTROL SYSTEMS
14	AGRICULTURAL SCIENCES, AGRICULTURE	55	BACTERIOLOGY
15	AGRI-FOOD, AGRI-ENVIRONMENT	56	BANKING
16	AGRONOMY	57	BENCHMARKING TECHNIQUES
17	AIR TRAFFIC CONTROL OPERATIONS/PROCEDURES/SLOT ALLOCATION	58	BIOASSAYS
18	AIR TRAFFIC MANAGEMENT/FLOW MANAGEMENT	59	BIOCATALYSTS
19	AIR TRANSPORT TECHNOLOGY	60	BIOCHEMICAL TECHNOLOGY
20	AIRCRAFT	61	BIOCHEMISTRY, METABOLISM
21	AIRPORT OPERATIONS/PROCEDURES	62	BIOCOMPUTING, MEDICAL INFORMATICS, BIOMATHEMATICS, BIOMETRICS
22	ALGAE	63	BIODEGRADATION
23	ALGEBRA	64	BIODIVERSITY
24	ALGEBRAIC TOPOLOGY	65	BIOFERTILIZERS
25	ALGORITHMS AND COMPLEXITY	66	BIOGAS PRODUCTION
26	ALLERGOLOGY	67	BIOLOGICAL COLLECTIONS: MUSEA AND RELATED INFORMATION RESOURCES
27	ALTERNATIVE PROPULSION SYSTEMS	68	BIOLOGICAL ENGINEERING
28	ANALYTICAL CHEMISTRY	69	BIOLOGICAL MONITORING/RISK FACTORS AND ASSESSMENT
29	ANIMAL BANKS AND REPOSITORIES	70	BIOLOGICAL SCIENCES, BIOLOGY
30	ANIMAL BIOTECHNOLOGY	71	BIOMASS PROCESS INTEGRATION AND ENVIRONMENTAL IMPACTS
31	ANIMAL BREEDING/REPRODUCTION/NUTRITION	72	BIOMECHANICS, BIOMEDICAL ENGINEERING
32	ANIMAL FEED, ANIMAL PRODUCTION	73	BIOMEDICAL ETHICS
33	ANIMAL HEALTH, ANIMAL WELFARE	74	BIOMEDICAL SCIENCES
34	ANIMAL PARASITIC DISEASES	75	BIOMOLECULES, BIOPLASTICS, BIOPOLYMERS
35	ANIMAL PHYSIOLOGY	76	BIOPHYSICS, MEDICAL PHYSICS
36	ANIMAL PRODUCTS	77	BIOREACTORS
37	ANTHROPOGENIC IMPACT ON ECOSYSTEMS	78	BIOREMEDIATION
38	ANTHROPOLOGY	79	BIOSAFETY
39	ANTIBIOTICS	80	BIOSENSORS
40	ANTICANCER THERAPIES	81	BIOTECHNOLOGY, BIOENGINEERING
41	ANTI-FRAUD	82	BIOTRANSFORMATION
		83	BOREAL FOREST
		84	BRAIN DEVELOPMENT

85	BRAIN THEORY, BRAIN MAPPING
86	BROADBAND TECHNOLOGIES
87	BROADCASTING
88	BROKERAGE SERVICES
89	BUILDING CONSTRUCTION, SHELL SUSTAINABILITY
90	BUSINESS COMMUNICATION
91	BUSINESS ECONOMICS/STUDIES, ORGANISATION AND PROCESSES
92	CARBOCHEMISTRY, PETROCHEMISTRY, FUELS AND EXPLOSIVES TECHNOLOGY
93	CARBOHYDRATES AND OTHER MACROMOLECULES METABOLISM
94	CARBON DIOXIDE CAPTURE/STORAGE/DISPOSAL
95	CARDIOVASCULAR SYSTEM
96	CARE AND HEALTH SERVICES, HELP TO THE HANDICAPPED
97	CELL COMMUNICATION
98	CENTRAL AND EASTERN EUROPEAN COUNTRIES
99	CERAMIC MATERIALS AND POWDERS
100	CERTIFICATION
101	CHEMICAL METROLOGY
102	CHEMICAL TECHNOLOGY AND ENGINEERING
103	CHEMISTRY/HOMOGENEOUS AND HETEROGENEOUS CATALYSIS/THEORETICAL/NANOCHEMISTRY
104	CHRONOLOGY, DATATION TECHNOLOGY
105	CIVIL ENGINEERING (INCL PAVEMENTS AND STRUCTURES)
106	CLINICAL GENETICS, BIOLOGY
107	CLINICAL PHYSICS, RADIOLOGY, TOMOGRAPHY, MEDICAL INSTRUMENTATION, MEDICAL IMAGING
108	CLINICAL RESEARCH, CLINICAL TRIALS, COMPUTERISED CLINICAL SYSTEMS
109	COAL MINING TECHNOLOGIES
110	COASTAL MORPHOLOGICAL CHANGES AND COASTAL DEFENSE MECHANISMS
111	COASTAL ZONE ECOSYSTEMS AND MANAGEMENT
112	COATS AND SURFACE TREATMENT
113	COGNITIVE SCIENCE
114	COLLOIDS
115	COMBINATORIAL CHEMISTRY
116	COMBINED HEAT AND POWER SYSTEMS
117	COMBUSTION BASICS AND EFFICIENCY
118	COMMERCIAL AND INDUSTRIAL ECONOMICS
119	COMMON AGRICULTURAL POLICY
120	COMMUNICATION ENGINEERING/TECHNOLOGY
121	COMMUNICATION SCIENCES/HUMAN COMPUTER INTERACTIONS
122	COMMUNITY DEVELOPMENT, COMMUNITY STUDIES
123	COMPANY RE-ENGINEERING/ORGANISATIONAL DEVELOPMENT
124	COMPOSITE MATERIALS
125	COMPUTATIONAL BIOLOGY
126	COMPUTATIONAL CHEMISTRY AND MODELING
127	COMPUTATIONAL MATHEMATICS/DISCRETE MATHEMATICS
128	COMPUTATIONAL PHYSICS
129	COMPUTER SCIENCE/ENGINEERING, NUMERICAL ANALYSIS, SYSTEMS, CONTROL
130	COMPUTER TECHNOLOGY/GRAPHICS, META COMPUTING
131	COMPUTER-BASED TRAINING
132	CONDENSED MATTER: ELECTRONIC, MAGNETIC AND SUPERCONDUCTIVE PROPERTIES
133	CONDENSED MATTER: MECHANICAL AND THERMAL PROPERTIES
134	CONDENSED MATTER: OPTICAL AND DIELECTRIC PROPERTIES
135	CONDENSED MATTER: SOFT MATTER AND POLYMER PHYSICS
136	CONSUMER SCIENCES, CONSUMERS' RIGHTS
137	CONTROL ENGINEERING
138	COOPERATIVE WORKING
139	CORROSION
140	COSMOLOGY
141	CRIMINOLOGY
142	CROP, CROP INPUTS/MANAGEMENT/YIELD ESTIMATION
143	CULTURAL HERITAGE: PRESERVATION AND RESTORATION/CULTURAL STUDIES
144	CULTURE COLLECTIONS: MICROBIAL, CELL, TISSUE, GERMPLASM
145	CURRICULUM STUDIES
146	CYBERNETICS
147	CYTOGENETICS
148	CYTOLOGY, CANCEROLOGY, ONCOLOGY
149	DATA PROTECTION, STORAGE TECHNOLOGY, CRYPTOGRAPHY

150	DATABASES, DATABASE MANAGEMENT, DATA MINING
151	DECENTRALISED GENERATION OF ELECTRICITY/HEAT
152	DECISION SUPPORT TOOLS
153	DEEP WATER EXPLOITATION
154	DEMOGRAPHY
155	DESIGN, DESIGN ENGINEERING
156	DEVELOPMENT OF CLEAN FUELS FOR TRANSPORT
157	DEVELOPMENT POLICIES AND STUDIES
158	DEVELOPMENT TECHNOLOGY, ANIMAL GROWTH, ONTOLOGY, EMBRYOLOGY
159	DIAGNOSTICS, DIAGNOSIS
160	DIGITAL SYSTEMS, DIGITAL REPRESENTATION
161	DISABILITIES, HANDICAPS AND HANDICAPPED
162	DISEASES: RARE/CHRONIC/DEGENERATIVE, ETIOLOGIC FACTORS
163	DIVERSIFICATION IN AGRICULTURE/FORESTRY
164	DNA CHIP
165	DNA THERAPIES
166	DOWNSTREAM PROCESSING
167	"DRILLING TECHNOLOGY; DEEP DRILLING"
168	DRUG ABUSE, ADDICTION
169	DRUG DISCOVERY, PROFILING, TARGETING
170	DRYLAND AND ARID ZONE ECOSYSTEMS
171	EARTH OBSERVATION APPLICATIONS AND POLICY
172	EARTH OBSERVATION TECHNOLOGY AND INFORMATION EXTRACTION
173	EARTH SCIENCE, EARTH OBSERVATION/STRATIGRAPHY/SEDIMENTARY PROCESSES
174	EARTH SCIENCES FOR CLIMATE RESEARCH
175	ECOLOGY, ECOSYSTEMS, ECOLOGICAL EVOLUTION/DYNAMICS
176	ECONOMIC AND ENVIRONMENT IMPACTS
177	ECONOMIC AND SOCIAL SCIENCES
178	ECONOMICS IN AGRICULTURE/FORESTRY/RURAL DEVELOPMENT
179	ECONOMICS OF DEVELOPMENT/GROWTH/INNOVATION
180	ECONOMICS, ECONOMIC PLANNING
181	ECOSYSTEM RESEARCH AND CONSERVATION
182	ECOTOXICOLOGY
183	EDUCATION AND TRAINING, LIFELONG LEARNING, REMOTE LEARNING
184	EDUCATIONAL MULTIMEDIA
185	EDUCATIONAL SCIENCES
186	ELECTRICAL ENGINEERING/TECHNOLOGY
187	ELECTROMAGNETISM
188	ELECTRONIC COMMERCE, ELECTRONIC PAYMENT, ELECTRONIC SIGNATURE
189	ELECTRONIC DATA INTERCHANGE
190	ELECTRONIC HEALTH RECORDS
191	ELECTRONIC PUBLISHING, AUTHORING TOOLS
192	ELECTRONICS, ELECTRONIC ENGINEERING
193	EMERGENCY MANAGEMENT
194	EMISSION
195	EMPLOYMENT STUDIES
196	ENDOCRINOLOGY, SECRETING SYSTEMS, DIABETOLOGY
197	ENERGY AND CLIMATE CHANGE
198	ENERGY CONVERSION PROCESSES OR CYCLES/CONVERSION FROM COAL
199	ENERGY MANAGEMENT SYSTEM
200	ENERGY MARKET ANALYSIS
201	ENERGY PRODUCTION FROM BIOMASS / WASTE
202	ENERGY RESEARCH/RTD POLICY
203	ENERGY, RENEWABLE ENERGIES, ELECTRICITY STORAGE
204	ENGINEERING, CONCURRENT ENGINEERING
205	ENTOMOLOGY, PLANT PARASITOLOGY
206	ENTREPRENEURSHIP, SPIN OFFS, NEW TECHNOLOGY BASED BUSINESS
207	ENVIRONMENT, ENVIRONMENTAL SCIENCE
208	ENVIRONMENTAL ECONOMICS/NATURAL RESOURCES ECONOMICS
209	ENVIRONMENTAL HEALTH
210	ENVIRONMENTAL IMPACTS/INTERACTIONS
211	ENVIRONMENTAL INDICATORS/MONITORING/RISK ASSESSMENT
212	ENVIRONMENTAL LAW/TREATIES/POLICY
213	ENVIRONMENTAL TECHNOLOGY/ENGINEERING, POLLUTION CONTROL
214	EPIDEMIOLOGY
215	ERGONOMICS
216	EROSION
217	EUROPEAN INTEGRATION

218	EUROPEAN LAW
219	EUROPEAN STUDIES
220	EVALUATION
221	EXPLOITATION OF RESEARCH RESULTS
222	EXTENSIFICATION
223	EXTERNALITIES
224	FARMHOUSE CONSTRUCTION
225	FARMING SYSTEMS
226	FERMENTATION
227	FINANCIAL SCIENCE, FINANCE
228	FINE CHEMICALS, DYES AND INKS
229	FISH/FISHERIES
230	FISHING METHODOLOGIES/SELECTIVITY
231	FOOD AND DRINK TECHNOLOGY
232	FOOD CHEMISTRY, FOOD INGREDIENTS
233	FOOD MICROBIOLOGY
234	FOOD PROCESSING/PACKAGING
235	FOOD QUALITY MANAGEMENT/POLICY/LABELLIN G
236	FOOD TOXICOLOGY
237	FOREST ECOSYSTEMS
238	FOREST GENETICS
239	FOREST PHYSIOLOGY AND PATHOLOGY
240	FOREST POLICY, FOREST MANAGEMENT
241	FOREST PROTECTION
242	FOREST SCIENCES
243	FORMAL SAFETY AND ENVIRONMENTAL ASSESSMENT
244	FREIGHT TRANSPORT
245	FUEL CELLS
246	FUELS: ALTERNATIVE FUELS IN TRANSPORTS
247	FUNCTIONAL FOODS
248	FUNGI
249	FUTURE AND EMERGING TECHNOLOGIES
250	GAS CONVERSION
251	GAS TURBINES FOR ENERGY CONVERSION
252	GASES, FLUID DYNAMICS, PLASMAS/ELECTRIC DISCHARGES
253	GASTRO-ENTEROLOGY
254	GENDER ISSUES, GENDER STUDIES
255	GENE THERAPY
256	GENERAL PATHOLOGY, PATHALOGICAL ANATOMY
257	GENETIC COMPARATIVE ANALYSIS
258	GENETIC ENGINEERING
259	GENETIC MAPPING, GENE SEQUENCE
260	GENETIC RESISTANCE
261	GENETIC SELECTION
262	GENETICALLY MODIFIED ORGANISMS
263	GENETICS
264	GENOMES, GENOMICS
265	GEOGRAPHIC INFORMATION SYSTEMS
266	GEOGRAPHY
267	GEOLOGICAL ENGINEERING/GEOTECHNICS
268	GEOMETRY/TOPOLOGY
269	GEOPHYSICS, PHYSICAL OCEANOGRAPHY, METEOROLOGY, GEOCHEMISTRY, TECTONICS
270	GERONTOLOGY AND GERIATRICS
271	GLOBAL CHANGE: BIOGEOCHEMICAL AND HYDROLOGICAL CYCLES
272	GLOBAL CHANGE: CLIMATE CHANGE
273	GLOBAL CHANGE: HUMAN HEALTH
274	GLOBAL CHANGE: LAND COVER AND DEGRADATION
275	GLOBAL CHANGE: OZONE AND ATMOSPHERIC COMPOSITION
276	GLOBAL CYCLES OF ENERGY AND MATTER
277	GREEN TECHNOLOGIES/CHEMICALS
278	GRID CONNECTION
279	HAZARDS: INDUSTRIAL
280	HAZARDS: NATURAL
281	HEALTH AND POPULATION, HEALTH EDUCATION
282	HEALTH FINANCING / ECONOMICS
283	HEALTH RISK EVALUATION
284	HEALTH SCIENCES/POLICIES/LAW
285	HEALTH SERVICE MANAGEMENT
286	HEALTH SYSTEMS RESEARCH
287	HEALTH, HEALTH PHYSICS
288	HETEROGENEOUS CATALYSIS
289	HIGH CONTAINMENT, HIGHT CONTAINMENT FACILITIES
290	HIGH FREQUENCY TECHNOLOGY, MICROWAVES
291	HIGH-THROUGHPUT SCREENING
292	HISTOLOGY, CYTOCHEMISTRY, HISTOCHEMISTRY, TISSUE CULTURE
293	HISTORY
294	HISTORY AND PHILOSOPHY OF SCIENCE AND MEDICINE
295	HOME SYSTEMS
296	HORMONES
297	HORTICULTURE, ORNAMENTAL PLANTS
298	HUMAN FACTORS IN TRANSPORT
299	HUMAN GENETICS
300	HUMAN RIGHTS
301	HUMAN SCIENCES, HUMANITIES
302	HVAC SYSTEMS AND MANAGEMENT
303	HYBRID AND ELECTRIC VEHICLES

304	HYDROBIOLOGY, MARINE BIOLOGY, AQUATIC ECOLOGY, LIMMOLOGY
305	HYDROCARBONS EXPLORATION AND PRODUCTION
306	HYDROELECTRICITY/SMALL HYDRO/HYDROPOWER
307	HYDROGEN
308	HYDROGEOLOGY, GEOGRAPHICAL AND GEOLOGICAL ENGINEERING
309	IDENTIFICATION SYSTEMS
310	IMAGING, IMAGE PROCESSING
311	IMMUNOLOGY, IMMUNOTHERAPY, IMMUNOASSAYS
312	IN VITRO TESTING/TRIAL METHODS
313	INDUSTRIAL ENGINEERING
314	INDUSTRIAL POLICY/RELATIONS
315	INDUSTRIAL PSYCHOLOGY/SOCIOLOGY
316	INDUSTRIAL TECHNOLOGY/ECONOMICS
317	INFECTIONS
318	INFORMATICS
319	INFORMATICS LAW
320	INFORMATION MANAGEMENT
321	INFORMATION TECHNOLOGY/SCIENCE
322	INFRASTRUCTURE MANAGEMENT
323	INLAND NAVIGATION
324	INNOVATION ASSISTANCE
325	INNOVATION FINANCE
326	INNOVATION MONITORING
327	INNOVATION POLICY/STUDIES
328	INNOVATION TRAINING
329	INORGANIC CHEMISTRY
330	INSECTS
331	INSTRUMENTATION TECHNOLOGY
332	INTANGIBLE INVESTMENTS
333	INTEGRATED ENVIRONMENTAL ASSESSMENT
334	INTEGRATED GLOBAL SAFETY
335	INTEGRATION OF RENEWABLE ENERGY SYSTEMS
336	INTELLECTUAL PROPERTY
337	INTELLIGENT AGENTS
338	INTELLIGENT VEHICLES AND WATERBORNE TRANSPORT SYSTEMS
339	INTERMODAL TRANSPORT
340	INTERNATIONAL COMMERCE/ECONOMICS
341	INTERNATIONAL TREATIES / MULTILATERAL AGREEMENTS
342	INTERNET TECHNOLOGIES
343	INVERTEBRATES
344	JOURNALISM
345	KNOWLEDGE ENGINEERING
346	LABOUR MARKET STUDIES/ECONOMICS
347	LAND USE PLANNING/LANDSCAPE/LANDSCAPE ARCHITECTURE
348	LANGUAGE SCIENCES/ENGINEERING/TECHNOLOGY, LINGUISTICS
349	LARGE SCALE GENERATION OF ELECTRICITY/HEAT
350	LASER TECHNOLOGY
351	LAW: INTERNATIONAL / PRIVATE / PUBLIC
352	LEARNING MECHANISMS
353	LIBRARY SCIENCE/SYSTEMS
354	LIFE CYCLE MANAGEMENT
355	LIPIDS, STEROIDS, MEMBRANES
356	LIQUID BIOFUELS
357	LOGISTICS
358	LOW INPUT PRODUCTION
359	MACROECONOMICS (INCL. MONETARY ECONOMICS)
360	MACROMOLECULAR CHEMISTRY/NEW MATERIAL/SUPRAMOLECULAR STRUCTURES
361	MACROSOCIOLOGY
362	MAINTENANCE MANAGEMENT
363	MANAGEMENT OF ENTERPRISES
364	MANAGEMENT OF URBAN AREAS
365	MANAGEMENT STUDIES
366	MARINE ECOSYSTEMS
367	MARINE SCIENCES/MARITIME STUDIES
368	MARINE: INSTRUMENTATION AND UNDERWATER TECHNOLOGY
369	MARINE: OCEANOGRAPHY (PHYSICAL AND OPERATIONAL)
370	MARITIME SAFETY
371	MARKET ANALYSIS/ECONOMICS/QUANTITATIVE METHODS
372	MARKET STUDY, MARKETING
373	MATERIALS TECHNOLOGY/ENGINEERING
374	MATHEMATICAL ANALYSIS/PARTIAL DIFFERENTIAL EQUATIONS
375	MATHEMATICAL LOGIC: SET THEORY, COMBINATORICS/SEMANTICS
376	MATHEMATICAL PHYSICS
377	MATHEMATICS
378	MECHANICAL ENGINEERING, HYDRAULICS, VIBRATION AND ACOUSTIC ENGINEERING
379	MEDIA STUDIES/LAW/MASS COMMUNICATIONS
380	MEDICAL ANTHROPOLOGY
381	MEDICAL SCIENCES/RESEARCH
382	MEDICAL TECHNOLOGY
383	MEDICINAL CHEMISTRY

384	MEDICINE (HUMAN AND VERTEBRATES)
385	MEMBRANE TECHNOLOGY
386	MENTAL STRESS
387	METABOLIC REGULATION AND SIGNAL TRANSDUCTION
388	METAL TECHNOLOGY AND METAL PRODUCTS
389	METALLURGY
390	METROLOGY, PHYSICAL INSTRUMENTATION
391	MICROBIAL BIOTECHNOLOGY, MICROBIAL MODELLING
392	MICROBIAL SYSTEMATICS/DIVERSITY
393	MICROBIOLOGY
394	MICROECONOMICS (THEORETICAL AND APPLIED)
395	MICROELECTRONICS
396	MICROENGINEERING, MICROMACHINING
397	MICROSYSTEMS
398	MINING
399	MOBILE COMMUNICATIONS
400	MODELLING/MODELLING TOOLS, 3-D MODELLING
401	MOLECULAR BIOLOGY
402	MOLECULAR BIOPHYSICS
403	MOLECULAR DESIGN, DE NOVO DESIGN
404	MOLECULAR EVOLUTION
405	MOLECULAR GENETICS
406	MOLECULAR MARKERS AND RECOGNITION
407	MONOCLONAL ANTIBODIES
408	MOTHER AND CHILD HEALTH
409	MOTORS AND PROPULSION SYSTEMS
410	MOUNTAIN AND HIGHLAND ECOSYSTEMS
411	MULTIMEDIA
412	MULTISENSORY TECHNOLOGY, MULTI-SENSING
413	MUSEUM SCIENCE
414	MYCOLOGY
415	NANOBIOTECHNOLOGY
416	NANOFABRICATION, NANOTECHNOLOGY
417	NARROW BAND TECHNOLOGIES
418	NATURAL GAS
419	NATURAL HISTORY OF DISEASES
420	NATURAL OILS, FATS AND WAXES
421	NATURAL RESOURCES EXPLORATION
422	NATURAL SCIENCES
423	NEMATODS
424	NETWORK TECHNOLOGY, NETWORK SECURITY
425	NETWORKED ORGANISATIONS
426	NEUROBIOLOGY, NEUROCHEMISTRY, NEUROLOGY, NEUROPSYCHOLOGY, NEUROPHYSIOLOGY
427	NEUROINFORMATICS
428	NEUTRON PHYSICS
429	NEW MEANS OF TRANSPORT
430	NITROGEN FIXATION
431	NOISE AND VIBRATIONS
432	NON-COMMUNICABLE DISEASES
433	NON-LINEAR DYNAMICS AND CHAOS THEORY
434	NON-METALLIC MINERAL TECHNOLOGY
435	NUCLEAR CHEMISTRY
436	NUCLEAR ENGINEERING AND TECHNOLOGY
437	NUCLEAR MEDICINE, RADIOBIOLOGY
438	NUCLEAR PHYSICS
439	NUCLEIC ACID METABOLISM
440	NUCLEIC ACIDS, POLYNUCLEAOTIDES, PROTEIN SYNTHESIS
441	NUMBER THEORY, FIELD THEORY, ALGEBRAIC GEOMETRY, GROUP THEORY
442	NUTRITION
443	OBSERVATION SYSTEMS / CAPACITY / DATASETS / INDICATORS
444	OCCUPATIONAL HEALTH, INDUSTRIAL MEDICINE
445	OCEAN / ENERGY
446	ODONTOLOGY, STOMATOLOGY
447	OFFSHORE TECHNOLOGY, SOIL MECHANICS, HYDRAULIC ENGINEERING
448	ON-LINE INFORMATION SERVICES, ON-LINE DEMOCRATY, ON-LINE BUSINESS
449	OPERATIONS RESEARCH, ACTUARIAL MATHEMATICS
450	OPTICAL MATERIALS
451	OPTICS
452	OPTRONICS
453	ORGANIC CHEMISTRY
454	ORGANIC FARMING
455	ORGANIC WASTE
456	ORGANOMETALLIC CHEMISTRY
457	ORPHAN DRUGS
458	OTHER RENEWABLE ENERGY OPTIONS
459	OTORHINOLARYNGOLOGY, AUDIOLOGY, AUDITIVE SYSTEM AND SPEECH
460	PALEOCLIMATOLOGY
461	PALEONTOLOGY/PALEOECOLOGY
462	PAPER TECHNOLOGY, RECYCLING
463	PARASITOLOGY (HUMAN AND ANIMAL)
464	PARTICLE PHYSICS/FIELDS THEORY

465 PASSENGER TRANSPORT
466 PATENTS, COPYRIGHTS, TRADEMARKS
467 PATHOLOGY
468 PATHOPHYSIOLOGY
469 PERIPHERALS TECHNOLOGIES (MASS DATA STORAGE, DISPLAY TECHNOLOGIES)
470 PERI-URBAN AGRICULTURE
471 PESTICIDES, BIOPESTICIDES
472 PETROCHEMISTRY, PETROLEUM ENGINEERING
473 PETROLOGY, MINERALOGY, GEOCHEMISTRY
474 PHARMACEUTICALS AND RELATED TECHNOLOGIES
475 PHARMACOLOGICAL SCIENCES, PHARMACOGNOSY, TOXICOLOGY
476 PHOTONIC NETWORKS
477 PHOTOVOLTAIC SYSTEMS, CELLS AND MODULES MANUFACTURING, TECHNOLOGY DEVELOPMENT
478 PHYSICAL CHEMISTRY/SOFT MATTER
479 PHYSICAL GEOGRAPHY, CARTOGRAPHY, CLIMATOLOGY
480 PHYSICAL MEDICINE, KINESITHERAPY, REVALIDATION, REHABILITATION
481 PHYSICAL SCIENCES
482 PHYSICAL STRESS
483 PHYSICS OF FLUIDS
484 PHYSIOLOGICAL DISORDERS
485 PHYSIOLOGY
486 PHYTOREMEDIATION
487 PHYTOTECHNOLOGY, PHYTOPATHOLOGY, CROP PROTECTION
488 PIPELINE TECHNOLOGY
489 PLANT AND ASSOCIATED MICROORGANISM BIOTECHNOLOGY
490 PLANT BIOCHEMISTRY
491 PLANT BIOLOGY
492 PLANT GENETICS/SELECTION/BREEDING
493 PLANT HEALTH/PROTECTION
494 PLANT INPUTS/NUTRITION/PRODUCTION
495 PLANT PHYSIOLOGY
496 PLANT PRODUCTS
497 POLITICAL SCIENCES/THEORY/ECONOMY/COMPARATIVE POLITICS
498 POLYMER TECHNOLOGY, BIOPOLYMERS
499 POPULATION GENETICS
500 PORT MANAGEMENT
501 POSITIONING AND GUIDANCE SYSTEMS
502 POST HARVEST TREATMENT - FOOD
503 POST HARVEST TREATMENT - NON-FOOD
504 PRECISION ENGINEERING
505 PRION DISEASES
506 PROBABILITY THEORY
507 PROCESS EFFICIENCY
508 PROCESS ENGINEERING
509 PRODUCTION TECHNOLOGY
510 PROGRAMMING/INFORMATION SYSTEMS
511 PROJECT ENGINEERING
512 PROTEINS, ENZYMOLOGY, PROTEIN ENGINEERING
513 PROTEOMES, PROTEOMICS
514 PSYCHIATRY, MEDICAL PSYCHOLOGY, PSYCHOSOMATICS
515 PSYCHOLOGICAL SCIENCES, PSYCHOLOGY
516 PUBLIC ADMINISTRATION
517 PUBLIC HEALTH
518 PUBLIC PERCEPTION, PUBLIC RELATIONS
519 PUBLIC POLICY STUDIES
520 PUBLISHING
521 PULP TECHNOLOGY
522 QUALITY, QUALITY CONTROL, TRACEABILITY
523 QUANTUM INFORMATION PHYSICS
524 QUANTUM MECHANICS
525 QUANTUM TECHNOLOGY
526 R&D POLICY AND PROGRAMME EVALUATION AND IMPACT ASSESSMENT
527 RADIODIAGNOSTICS, RADATION BIOLOGY
528 RADIOECOLOGY
529 RAILWAY TRANSPORT TECHNOLOGY
530 REACTION MECHANISMS AND DYNAMICS
531 REACTOR SAFETY
532 REFERENCE MATERIALS/METHODS
533 REFRIGERATION AND COOLING
534 REGIONAL ECONOMICS/STUDIES/ DEVELOPMENT
535 REHABILITATION SYSTEMS
536 REMOTE SENSING
537 REPRODUCTIVE HEALTH
538 REPRODUCTIVE MECHANISMS
539 RESEARCH METHODOLOGY IN SCIENCE
540 RESEARCH NETWORKING
541 RESEARCH POLICY
542 RESERVOIR CHARACTERISATION AND MONITORING
543 RESIDUES
544 RESPIRATORY SYSTEM
545 RE-STRUCTURING OF PUBLIC ADMINISTRATIONS

546 ROAD SAFETY
547 ROAD TRANSPORT TECHNOLOGY
548 RTD SYSTEMS AND POLICIES AND THEIR INTERACTION WITH OTHER RELATED POLICIES
549 RURAL DEVELOPMENT, RURAL SOCIOLOGY AND SOCIO-ECONOMICS
550 SAFETY TECHNOLOGY
551 SAMPLE BANKS
552 SATELLITE (TECHNOLOGY, SYSTEMS, POSITIONING, COMMUNICATION)
553 SCIENCE AND TECHNOLOGY INDICATORS
554 SCIENCE POLICY
555 SCIENCE, TECHNOLOGY AND THE MEDIA
556 SEA FOOD
557 SEARCH AND RESCUE
558 SECURITY SYSTEMS
559 SEMICONDUCTOR PHYSICS AND TECHNOLOGIES
560 SENSORY SCIENCE, SENSORS, INSTRUMENTATION
561 SEROLOGY AND TRANSPLANTATION
562 SET ASIDE
563 SIGNAL PROCESSING
564 SILVICULTURE, FORESTRY, FOREST TECHNOLOGY
565 SIMULATION, SIMULATION ENGINEERING
566 SIMULATOR TRAINING
567 SKELETON, MUSCLE SYSTEM, RHEUMATOLOGY, LOCOMOTION
568 SMART CARDS
569 SOCIAL ECONOMICS
570 SOCIAL LAW
571 SOCIAL MEDICINE
572 SOCIAL SHAPING OF TECHNOLOGY
573 SOCIETAL BEHAVIOUR
574 SOCIO-ECONOMIC ASPECTS OF ENVIRONMENTAL CHANGE
575 SOCIO-ECONOMIC RESEARCH
576 SOCIO-ECONOMICAL IMPACTS IN AGRICULTURE/FORESTRY/RURAL DEVELOPMENT
577 SOCIO-ECONOMICS
578 SOCIOLOGY
579 SOFTWARE ENGINEERING, MIDDLEWARE, GROUPWARE
580 SOIL SCIENCE, AGRICULTURAL HYDROLOGY, WATER PROCESSES
581 SOLAR CONCENTRATING TECHNOLOGIES AND APPLICATIONS
582 SOLID STATE PHYSICS
583 SOUND ENGINEERING /TECHNOLOGY
584 SPACE TECHNOLOGY
585 SPATIAL INTEGRATION IN BUILT ENVIRONMENT
586 SPEECH COMMUNICATION
587 SPEECH PROCESSING/ TECHNOLOGY
588 STANDARDISATION, STANDARDISATION OF NEW TECHNOLOGIES
589 STATISTICAL PHYSICS
590 STATISTICS
591 STRUCTURAL BIOLOGY/DETERMINATION/FUNCTION
592 SUPERCONDUCTORS
593 SURFACE CHEMISTRY
594 SURFACE PHYSICS
595 SURVEILLANCE
596 SURVEYING
597 SYNTHESIS AND NEW MOLECULES
598 SYSTEMS ANALYSIS AND MODELS DEVELOPMENT
599 SYSTEMS DESIGN/THEORY
600 SYSTEMS ENGINEERING
601 SYSTEMS, CONTROL, MODELLING, AND NEURAL NETWORKS
602 TECHNOLOGICAL SCIENCES
603 TECHNOLOGY ACCEPTABILITY
604 TECHNOLOGY ASSESSMENT AND FORESIGHT
605 TECHNOLOGY EVALUATION/MANAGEMENT
606 TECHNOLOGY POLICY
607 TECHNOLOGY TRANSFER
608 TECHNOLOGY WATCH/ VALIDATION
609 TELECOMMUNICATION ENGINEERING/TECHNOLOGY
610 TELESERVICES, TELE-WORKING, TELE-PAYMENT, TELE-MEDICINE
611 TESTING, CONFORMANCE TESTING
612 TEXTILES TECHNOLOGY
613 THERAPEUTIC SUBSTANCES
614 THERMAL ENGINEERING, APPLIED THERMODYNAMICS
615 THERMODYNAMICS
616 TIMBER ENGINEERING
617 TISSUE BANKS/ENGINEERING
618 TOTAL QUALITY MANAGEMENT
619 TOWN AND COUNTRY PLANNING
620 TOXICITY AND TOXINOLOGY
621 TRACTION/PROPULSION SYSTEMS
622 TRAFFIC CONTROL SYSTEMS
623 TRAFFIC ENGINEERING/INFRASTRUCTURE/ MANAGEMENT SYSTEMS
624 TRANSACTION SYSTEMS
625 TRANSGENE EXPRESSION
626 TRANSGENIC CROP PLANT
627 TRANSHIPMENT SYSTEMS
628 TRANSPORT DEMAND MANAGEMENT

629	TRANSPORT ECONOMICS
630	TRANSPORT INFORMATION SYSTEMS, FLEET MANAGEMENT
631	TRANSPORT INFRASTRUCTURE/MANAGEMENT SERVICES
632	TRANSPORT MODELLING/SCENARIOS
633	TRANSPORT OF GAS AND LIQUID FUELS
634	TRANSPORT POLICY/LAW
635	TRANSPORT SAFETY/SECURITY
636	TRANSPORT TECHNOLOGY/ENGINEERING
637	TRANSPORT TELEMATICS
638	TRANSPORT, TRANSMISSION AND DISTRIBUTION OF ELECTRICITY
639	TROPICAL AGRICULTURE
640	TROPICAL ECOSYSTEMS
641	TROPICAL FORESTRY
642	TROPICAL MEDICINE
643	URBAN DEVELOPMENT/ ECONOMICS
644	URBAN FORESTRY
645	URBAN GOVERNANCE AND DECISION MAKING
646	URBAN QUALITY OF LIFE
647	URBAN SOCIOLOGY
648	URBAN TRANSPORT
649	URBAN: SUSTAINABLE CITIES AND RATIONAL RESOURCE MANAGEMENT
650	URBAN: TECHNOLOGIES FOR THE BUILT ENVIRONMENT
651	UROLOGY, NEPHROLOGY
652	USER CENTRED DESIGN, USABILITY
653	USER MODELLING
654	VACCINES
655	VACUUM/HIGH VACUUM TECHNOLOGY
656	VEHICLE TECHNOLOGY
657	VENTURE CAPITAL
658	VESSEL TRAFFIC MANAGEMENT
659	VETERINARY MEDICINE
660	VIRTUAL ORGANISATIONS
661	VIRTUAL REALITY
662	VIRUS, VIROLOGY
663	VULCANOLOGY/SEISMOLOGY
664	WASTE BIOTREATMENT
665	WASTE MANAGEMENT/ RECYCLING
666	WATER RESOURCE MANAGEMENT/ENGINEERING
667	WATER TRANSPORT TECHNOLOGY, SHIPBUILDING
668	WATER: FRESH WATER ECOSYSTEMS
669	WATER: HYDROLOGY
670	WATER: MONITORING / QUALITY / TREATMENT
671	WATER: RATIONAL AND EFFICIENT USE
672	WATERBORNE TRANSPORT
673	WAVE/TIDAL ENERGY
674	WEEDS
675	WELFARE STUDIES
676	WETLAND ECOSYSTEMS
677	WIND ENERGY MANUFACTURING/TECHNOLOGIES
678	WIND TURBINE ENVIRONMENTAL IMPACT
679	WIRELESS SYSTEMS, RADIO TECHNOLOGY
680	WOMEN'S STUDIES
681	WOOD ENGINEERED PRODUCTS, PARTICLE AND FIBRE BOARDS
682	WOOD PROCESSING BY MECHANICAL MEANS
683	WORLD TRADE ORGANISATION

ANNEX 3: NACE codes for business activities

Division	Description
Section A	*Agriculture, hunting and forestry*
01	Agriculture, hunting and related service activities
02	Forestry, logging and related service activities
Section B	*Fishing*
05	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
Section C	*Mining and quarrying*
10	Mining of coal and lignite; extraction of peat
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12	Mining of uranium and thorium ores
13	Mining of metal ores
14	Other mining and quarrying
Section D	*Manufacturing*
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
35.1	Building and repairing of ships and boats
35.2	Manufacture of railway and tramway locomotives and rolling stock
35.3	Manufacture of aircraft and spacecraft
a	*Manufacture of helicopter*
b	*Manufacture of aeroplanes for the transport of goods or passengers, for use by the defence forces, for sports or other purposes*
c[1]	*Manufacture of parts and accessories of the aircraft of this class*
d[2]	*Others*
36	Manufacture of furniture; manufacturing n.e.c.

[1] Includes: major assemblies such as fuselages, wings, doors, control surfaces, landing gear, fuel tanks, nacelles, airscrews, helicopter rotors and propelled rotor blades, motors and engines of a kind typically found on aircraft, parts of turbojets and turbopropellers

[2] This includes: manufacture of gliders, hang-gliders, manufacture of dirigibles and balloons, manufacture of spacecraft and spacecraft launch vehicles, satellites, planetary probes, orbital stations, shuttles, manufacture of aircraft launching gear, deck arresters, etc. manufacture of ground flying trainers However 35.3 should **exclude**:manufacture of parachutes, military ballistic missiles, ignition parts and other electrical parts for internal combustion engines, instruments used on aircraft, and air navigation systems.

37	Recycling
Section E	*Electricity, gas and water supply*
40	Electricity, gas, steam and hot water supply
41	Collection, purification and distribution of water
Section F	*Construction*
45	Construction
Section G	*Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods*
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
Section H	*Hotels and restaurants*
55	Hotels and restaurants
Section I	*Transport, storage and communication*
60	Land transport; transport via pipelines
61	Water transport
61.1	Sea and coastal water transport
e	*Transport of passenger or freight over water*
f	*Operation of excursion, cruse or sightseeing boats*
g	*Operation of ferries, water taxis, etc.*
62	Air transport
h	*Transport of passenger or freight by airlines*
63	Supporting and auxiliary transport activities; activities of travel agencies
63.1	*Cargo handling and storage*
63.2	*Other supporting transport activities*
i	*Operation of terminal facilities such as harbours and piers, waterway locks etc.*
j	*Airport and air-traffic control activities*
63.3	Activities of travel agencies and tour operators; tourist assistance activities n.e.c.
63.4	Activities of other transport agencies
k	*Forwarding of freight*
64	Post and telecommunications
Section J	*Financial intermediation*
65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation
Section K	*Real estate, renting and business activities*
70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and households goods
72	Computer and related activities
73	Research and development
l	*Research and experimental development on natural sciences and engineering*
m	*Research and experimental development on social sciences and humanities*
74	Other business activities
Section L	*Public administration and defence; compulsory social security*
75	Public administration and defence; compulsory social security
Section M	*Education*
80	Education
Section N	*Health and social work*
85	Health and social work
Section O	*Other community, social and personal service activities*
90	Sewage and refuse disposal, sanitation and similar activities
91	Activities of membership organisations n.e.c.
92	Recreational, cultural and sporting activities

93	Other service activities
Section P	*Private households with employed persons*
95	Private households with employed persons
Section Q	*Extra-territorial organisations and bodies*
99	Extra-territorial organisations and bodies