Executive Summary:

In the CleanCloth project, a superior cleaning cloth with constant and continuous antibacterial effect will be developed, ensuring that no bacteria is left in the cloth and making bacterial re-growth impossible, without the need for special and time-consuming hygiene procedures.

Infectious diseases arising in the home setting are a significant concern. Although a proportion of these infections are caused by direct person-to-person interaction or consumption of contaminated food, evidence shows that a significant amount of infections, not only food-borne but also person-to-person, relate to cross contamination via hands, surfaces or other bacteria containing objects such as the kitchen-cloth.

In Europe, there are annually about 24 million cases reported of illness due to microbial contamination. However, studies demonstrate that this number is actually much higher, probably a factor of 10, due to the mild cases not being reported. The possibility of reducing absence from work and hospitalisation due to hygiene related sickness would have a great positive impact on the economy, both considering the savings achieved in the companies experiencing absence of employees due to sickness but also savings achieved by reduced hospitalisation frequency. Social impact studies demonstrate that disease due to microbial contamination directly causes approximately 14.000 man-years being lost in Europe annually, representing an estimated cost of more than 50 Billion Euro in medical costs and lost productivity.

The Cleancloth project will seek to significantly improve the antibacterial efficiency of microfiber cloths for cleaning purposes and in this way reduce the risk of cross contamination of bacteria and bacteria transfer. To perform this work, the National Institute of Technology (Norway), CenTexBel (Belgium), ITCF Denkendorf (Germany) and Swerea (Sweden) were chosen as the R&D Performers. They provide extensive, and complimentary, resource and facilities for research and development of technology within cleaning, material technology, textiles and polymer processing. Together, they also have all the facilities required for performing the testing needed for development of the new antibacterial cloth.

The idea behind Cleancloth is to develop a microfiber cloth for cleaning purposes that is superior in antibacterial effect to products available today.

The Scientific Objectives of the project hence have been:

- Enhanced understanding about antibacterial agents directed towards especially potentially pathogenic bacteria present in the home environment as well as in commercial kitchens and public areas such as hotels and health-care institutions.

- Describe and model bacterial regrowth and bacterial transfer from one surface to another and from one material to another.

- Define the specific requirements concerning integration of such antibacterial agents into a polymer matrix, including such parameters as resulting antibacterial effect of the developed microfiber, compatibility of antibacterial agent with the polymer material into which it is mixed as well as compatibility with the processing of the microfiber in regard to temperature-resistance and effect on splitting of the microfiber.

The Technological Objectives have been:

- Select an antimicrobial agent which is on the Commission Regulation EC No 1451/2007 for approval under the European Biocidal Products Directive 98/8/EC, product-type 2 and product-type 4 for incorporation into the polymer matrix of the masterbatch and meeting the requirements of the extrusion process.

- Development of an innovative antimicrobial microfiber of maximum size 0.3 dtex, a breaking tenacity of minimum 3.30 cN/dtex and breaking elongation of minimum 18%

- Development of an antimicrobial cloth with intrinsic antibacterial effect that will disable bacteria in less than 3 hours without regrowth and with a permanent antimicrobial effect that does not diminish over time and with a sales price of less than € 10 per unit.

Work Progress – Period 1

In Period 1 work was initiated by evaluating the biocides listed in Annex 1 under the Biocidal Products Directive 98/8/EC and the relevant non-inclusion documents listed. With this basis, a list of biocides for further detailed specification was created where all relevant information was collected; physical properties, chemical structure, prior use as biocide, toxicity and more. As the process of producing microfiber is limiting the number of substances that are applicable, the boiling point and decomposition temperature were used as first selection criteria for candidates that would be able to withstand the manufacturing process. After this evaluation, the work with sourcing the substances was initiated.

The received biocides were first analysed by TGA, Themogravimetric Analysis, which was applied in order to determine the weight loss of a sample when exposed to heat according to a special temperature program. The TGA results and the information gathered about the substances were the basis for an individual evaluation for each and every biocide in regard to

compatibility with the chosen resins, possible degradation products during processing, any risk for personell handling the processing, risk for damage on equipment etc. The evaluation concluded in two groups of compounds, PET-based and PP-based. From the compounded materials, plaques for testing of antibacterial effect were produced. The testing of the antibacterial effect was performed using the Film Contact method (for plaques) and the Absorption method (for textile). Both methods are needed as the testing on plaques requires fewer processing steps and will give an indication on antibacterial effect, however, it is necessary to be able to correlate these results with tests on textile. By the end of Period 1 the project has identified two very promising candidates for Cleancloth and in period 2 focus will be on continuing the evaluation of these two candidates.

The main results at the end of period 1 were:

- A set of biocides with high antibacterial effect in PET
- A set of biocides with high antibacterial effect in PP
- Information gathered on the properties of the system, particle size of biocides, particle size distribution, rheology, effect of biocide on base polymer
- Knowledge of the antibacterial effect of biocides when integrated into a polymer system – for all biocides analysed
- Recognition of parameters that will be very important for the final product and that will require focus and attention in period 2.

Work Progress – Period 2

In period 2, the work has mainly focussed on producing fiber from compounds of the two biocide candidates identified in period 1. Fiber has been produced at Swerea and Hofmann GmbH, with personnel from ITCF. Achieving good fiber has required intense work, using different routes of dispersing the biocide in the polymer.

The trials done on grinding of biocide down to the desired target of 400-500nm proved difficult due to the formation of agglomerates. A more time effective way to check the effect of smaller size agent A was found to be by using a nanosize grade commercially available. The consortium is aware that this size is significantly smaller than the 400-500nm targeted and that the distribution in the fiber and the availability in the fiber surface will be different. However, the route was tested for production of microfiber with integrated biocide due to the desired size range not being available. It has proven difficult to distribute and disperse small particles from powders in the compounding process. It has thus been identified necessary to disperse the particles in a solvent or other carrier before being added to the PET polymer. The

purpose of such treatment was to facilitate the dispersion of the particles in the polymer melt, whether it is being added in the compounding process or directly during the melt spinning process. A commercially available modification of agent A was identified as one such interesting possibility. In addition, the producer also produced a similar modified agent A from nanosize powder delivered to them from the Cleancloth consortium. The production of agent A containing microfiber was very challenging due to either dispersion problems or problems with the modified additive causing fiber breakage. In the end, very good results in antibacterial testing was achieved using a coarser (around 2 denier) fiber and the prototype cloth was therefore produced using this fiber in combination with 50 % standard PA/PET microfiber yarn. The prototype 2 was knitted at Hofmann GmbH with personnel from ITCF, cut and sewn at Syverket in Borås, Sweden and finally split by chemical splitting at The Swedish School of Textiles.

Compared to the work with agent A, the PA/PP based fiber with agent B was easier to work with. Initially there were some problems in regard to the cross-sections of the fibers not being satisfactorily uniform. The centre PA “spoke” shape was uneven and the PP phase pie segments were of different sizes. At the outer edge of each filament the PP phase had cut into the PA material and in some cases flowing together with neighbouring PP pie segments. The solution was to instead use a PP grade with higher melt viscosity at the processing temperature and the experienced shear rates. This produced very good quality fiber with perfect geometry. The prototype 1 was knitted at Engtex AB, cut and sewn at Syverket in Borås, Sweden and finally split by warm water.

The main results at the end of period 2 were:

- Successful fiber production using both agents A and B
- Successful production of textile using these yarns
- Both textiles cut and sewn into cloth and split successfully
- End-user tests performed
- Biological activity testing at site of End-User performed
- Cleaning efficiency testing of both cloths up against a standard consumer product as well as a standard Norwex microfiber cloth.

For further information on the project, please visit our homepage www.cleanclothproject.com or contact:

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Project Context and Objectives:

Cleancloth refers to the development of a superior microfiber cleaning cloth with constant and continuous antibacterial effect, ensuring that no bacteria is left in the cloth and making bacterial re-growth impossible, without the need for special and time-consuming hygiene procedures as is used today for cleaning utensils. The idea is to integrate the biocidal effect within the microfiber and thereby enable bacteria reduction and kill using only water at cleaning. There will be no need for cleaning chemicals and the antibacterial effect is constant as the chosen biocide does not work through leaching. Microfiber is already well-known for its ability to effectively clean surfaces and the combination of microfiber and antibacterial functionality makes up a product very well suited for e.g. restaurant kitchens, hotels and hospitals. Norwex has a product today with an antibacterial functionality, but Cleancloth is to greatly enhance the effectivity of the cloth, reducing the time for killing bacteria from 18 hours to under 3 hours. Reducing the killing time is very important considering storage of cloths and the rate at which they are used; in an ordinary cloth the level of bacteria would increase exponentially during storage, with increased risk of cross contamination to hands and between surfaces as a consequence.

Infectious diseases arising in the home setting are a significant concern. Although a proportion of these infections are caused by direct person-to-person interaction or consumption of contaminated food, evidence shows that a significant amount of infections, not only food-borne but also person-to-person, relate to cross contamination via hands, surfaces or other bacteria containing objects such as the kitchen-cloth or other types of cleaning cloths.

In Europe, there are annually about 24 million cases reported of illness due to microbial contamination. However, studies demonstrate that this number is actually much higher, probably a factor of 10, due to the mild cases not being reported. Of the reported cases of illness due to microbial contamination, more than 800.000 resulted in consultancy in the emergency department of a hospital, approximately 170.000 were hospitalized and 6.500 deaths are reported annually. The primary causes for diseases due to microbial contamination include salomonella, campylobacter, parasites and listeria.

Pathogenic and potentially pathogenic species are introduced as microbial contamination into the home and public places such as hospitals, day care centres, offices and hotels on a regular basis via people, pets and insects as well as in food, water and via air. Wet sites, such as kitchen areas, toilets and bathrooms are most commonly associated with heavy contamination and potentially harmful species. However, other wet sites such as dishcloths and cleaning utensils have also been found to be heavily contaminated. Contamination in the kitchen is most frequently caused by raw food, but the sink, waste trap and surrounding areas can also act as semi-permanent sources or reservoirs of bacteria. Gram negative species such as E. Coli, klebsiella spp. and pseudomonads have been shown to grow to substantial numbers in

sink U-tube and toilet water, as well as in contaminated wet cloths. Additionally, potentially harmful organisms are quite often isolated from hand and food contact surfaces in the bathroom and toilet as well as in the kitchen . The reservoir/disseminator sites such as wet cloths and cleaning utensils have a high risk of bacteria being present, a constant risk for spread of bacteria and are always in need for adequate hygiene procedures.

In order to achieve disinfection of cleaning cloths for professional use the required hygiene procedures are quite extensive including use of detergents and heat for a certain period of time. Studies have in fact shown that detergent based cleaning with rinsing produce little or no reduction in contamination levels, indicating that the micro-organisms are strongly adhered to the cloth fibres. Post disinfection storage of disinfected cloths can produce re-growth of residual survivors infecting the disinfected cloth before next use. The cloth developed by Norwex would require no cleaning chemicals, leading to reduced discharge of household and cleaning chemicals; in addition, the extensive hygiene procedures required to disinfect standard cloths would not be necessary. By integrating the antibacterial functionality into the microfiber structure, with the biocide contained within the fiber, there will be no need for cleaning chemicals. The biocidal action will be constant and continuous, killing bacteria contained within the cloth even as it is stored, wheras a standard cloth would experience a growth in the level of bacteria as bacteria thrive in a moist environment and show an exponential growth in number. The amount of biocide needed is very low using this approach, and only substances on the review list for the Biocidal Products Directive have been taken into consideration.

In reporting period 2 work has progressed in the following Work Packages:

- WP 3 Knitting of selected microfiber into cloth and testing of antibacterial properties
- WP 4 Testing of Cleancloth cleaning efficiency
- WP 5 Industrial Validation
- WP 6 Training
- WP 7 Innovation Related Activities
- WP 8 Demonstration

Project objectives for period 2 were:

- Further testing on cloth material is necessary to make the final choice. Testing of antibacterial efficiency is performed together with testing of physical properties of the resulting textile material. The antibacterial effect and physical properties together will be the

basis of the final choice of antibacterial agent for CleanCloth. Production of 500 cloths for end-user validation

- Testing of CleanCloth according to testing procedures developed at TI, cleaning efficiency on dust, friction, indulgence and cleaning efficiency on spots. Include testing on leaching of antibacterial agent and reaction to mechanical influence such as laundry. Test results will be compared to results on similar products already in the TI database

- Testing of the CleanCloth technology in hotel environment and in professional cleaning. Validate that the technology created is capable of decontaminating surfaces according to the goals set up. The validation was performed by taking samples before and after cleaning of selected areas and surfaces. A questionnaire was used to gather end-user ratings and comments on the product performance.

- Perform training of the participating end-users on the use of the technology developed in the project. The training will enable them to further train other members of the Radisson group.

- Protection of project results and development of Exploitation strategy.

The deliverables for the period were:

- Microfibre produced for testing
- Results of antibacterial and physical property testing
- Cloths produced for end-user validation
- Test report on cleaning efficiency
- Questionnaire delivered
- Report on questionnaire results
- Workshop on use of Cleancloth
- Patent search and patent application
- Dissemination activities
- Demonstration sessions conducted
- Project website
- Dissemination and Use Plan

Project Results:

WorkPackage 1: Scientific understanding of antibacterial agents for use in microfiber and evaluation of fiber material.

WP1 - Objectives:

- To investigate antibacterial agents for use in microfibre extrusion regarding temperature resistance, compatibility with polymer matrix and time-frame of antibacterial effect.

- Review of antibacterial agents used in cleaning utensils and evaluation of their antibacterial effect. Only biocides on the review list for approval according to the Biocide Directive (product type 2 and 4) will be considered.

- Evaluation of polymer type compatibility to choose which matrix (PA, PP or PET) should be used as the base for the antibacterial agent addition. Detail type of microbes targeted by selected agents. Analyse the material types and grades used for production of microfibre, especially processing temperature and sensitivity to chemicals, with focus on the type of chemicals that make up the antibacterial agents.

Throughout WP 1 work has been coordinated by Teknologisk Institutt working on biocide selection, sourcing of biocides, gathering of information on biocides in regard to chemical composition, previous use, toxicity, physical properties etc as well as health and safety issues. Compounding work has been performed by Swerea where TGA analysis has also been performed; TGA analysis has also been performed at ITCF as some biocides needed to be run with less sensitive equipment. All antibacterial effect testing has been done at Centexbel. In WP 1, all RTDs have been working closely together in order to get results as fast as possible and to go around any problems arising, TI has been the lead RTD coordinating the work. Throughout the work the coordinator has been closely monitoring the work performed. The tasks under WP1 go into each other and the work cannot be entirely separated into tasks as results in one task are also important results in another.

Task 1.1 Enhanced understanding of antibacterial agents towards pathogenic bacteria for use in antibacterial cloth

Task 1.1 – Activity and Results in Reporting Period 1:

Under task 1.1 a complete list of biocides on the list for approval under the European Biocidal Products Directive 98/8/EC has been set up. The list includes biocides that are on the Commission Regulation (EC) No 1451/2007 to the Biocide Directive (registered for product type 2 and/or 4). The following documents in regard to the non-inclusion of substances in Annex I, IA or IB to Directive 98/8/EC have also been taken into consideration:

Commission decision 2008/681/EC

- Commission decision 2008/809/EC
- Commission decision 2008/322/EC
- Commission decision 2008/324/EC
- Commission decision 2008/72/EC
- Commission decision 2008/71/EC

The biocide for use in the CleanCloth project needs to fulfil a specific set of criteria in order to be a functional part of the final product. In addition to the obvious requirement of biocidal action the substance to be used must also withstand the processing temperature at masterbatch production and fiber extrusion. This temperature is determined by the choice of polymer resin for the part of the microfiber structure that will carry the biocide. The most likely candidates at the outset were PA, PET and PP with approximate processing temperatures of 250-275 □C, 295 □C and 200 □C. The most desirable resin for use is PET as it is the resin used today and it is therefore known and experience with using it is available in the consortium. In addition, PET is the resin with the highest percentage in the cloth and would therefore be able to carry more biocide than PA. Another important reason for PET being the preferred choice is that by using PET, chemical splitting of the microfiber components can be used, thereby enabling dyeing to be performed simultaneously with the splitting process. This is not a possibility when using PP as mechanical splitting must then be used. However, this property is not an absolute necessity and the possibility of using other resins is therefore kept open. PP would in that case replace PET and be the resin of the highest percentage in the microfiber cloth. PA was decided to be the least preferred option as it has a rather high processing temperature combined with lower percentage in the cloth.

Currently, only a few active substances are approved under the biocidal products directive, none of these are in product-type 2 or 4. Instead, substances to be evaluated must be included in Commission Regulation (EC) No 1451/2007, table Active substances to be examined under the review programme. The biocides included on this list was further analysed taking into consideration other EU documents regarding “Existing active substances for which a decision of non-inclusion into Annex I or IA of Directive 98/8/EC has been adopted” . The development has been followed through

http://ec.europa.eu/environment/biocides/non_inclusions.htm . All biocides facing a phase-out were thereby removed from the list of available biocides. The initial list of 168 substances was in this way reduced via the phase-out document and the product type distinction (product type 2 and 4) down to 74 substances. This list of biocides was then gone through evaluating all substances in regard to boiling point, as no substance with a boiling point below the processing temperature will be a possibility in this case. The limit was set at 230 °C. When work had already progressed in regard to the original biocides list a new non-inclusion document excluded another substance from the list of options, this one was then in-house but not compounded. TI has produced a complete list of the biocides evaluated and the evaluation made. This list is available as a separate file uploaded on ECAS.

Another extremely important parameter for use in CleanCloth is the decomposition temperature. This property is not very often specified and the project has therefore decided to perform TGA analysis on the biocides that we receive where this property is unknown. A biocide for CleanCloth should not have a decomposition temperature below the processing temperature unless a very low percentage of the material is lost, although it will also be taken into consideration that the behaviour in the resin may not be exactly the same. Another very important aspect that has been taken into consideration is the likely behaviour of the substance during processing. Before compounding of biocide and polymer TI and Swerea have discussed the substances, biproducts at degradation, development of harmful gas etc and taken a decision on whether or not compounding is safe and whether the substance should be compounded into PET or PP.

Activity in task 1.1 is primarily performed by Teknologisk Institutt AS as task leader, but in all of WP 1 there has been a close cooperation between all RTDs. The work in task 1.1 is coordinated with activity in all other tasks in WP1. In addition, contribution from other RTD partners to task 1.1 does include:

- Assistance in sourcing of biocides.
- TGA analysis of aquired biocides
- Evaluation of safety at processing
- Selection of PET and PP grades

Task 1.1 - Deviations & Corrective Actions:

The work for Task 1.1 has been delayed due to the biocides on the list of possible candidates not being commercially available. Great effort was put into the sourcing of these substances but not all have yet been accessed. However, the work is proceeding continuously with the biocides that have been sourced and we do not foresee that this will be a problem as it has

been decided that a selected number of biocides which are judged as promising will possibly be synthesised by the consortium outside of the project budget.

Task 1.1 – Use of resources

The work has been focused on the following:

TI:

- Research into the Biocidal products directive
- Set up of main list of biocides in the correct product type and not on any non-inclusion document
- Literature study and database searches for chemical composition, physical properties, toxicity classification, prior use as biocide, any known biocidal action, suppliers and set up of a datafile with all biocides inclus
- ing all known information on these
- Evaluation of substances on the list in regard to applicability in Cleancloth
- Sourcing of biocides through databases, telephone contact, email contact, discussions with the larger suppliers such as Sigma-Aldrich and VWR International
- Ordering of biocides and order follow up
- Distribution of biocides to Swerea IVF
- Research into rules and regulations, cost and more for placing a new substance for approval according to the European Biocidal Products Directive

Swerea:

- Assistance in sourcing of biocides
- Handling o received biocides

Norwex:

- Delivery of all details on production process to TI
- Comments on important aspects in regard to the process

PP Polymer:

- Initial work to prepare for potential synthesis of unsourcable biocides

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6.

Task 1.2 Evaluation of compatibility of polymer with antibacterial agents

Work concentrating on evaluation of biocide physical properties in regard to compounding with polymer material. The biocides have been analysed by TGA to investigate the biocide decomposition temperature and behaviour during temperature increase, this information is then related to the polymer processing temperature. The resulting compound has also been analysed by TGA to evaluate any polymer degradation by the biocide.

Task 1.2 – Activity and Results in Reporting Period 1:

The main task for Swerea was Task 1.2 – Evaluation of compatibility of polymer with antibacterial agents (Swerea task leader) Evaluation of the compatibility of polyamide, polypropylene and polyester with the antibacterial agents in regard to mixing as well as processing conditions and microfiber splitting. Swerea, assisted by TI will evaluate the compatibility of the resin/agent blends based on chemistry, chemical sensitivity and processing temperature. Detail antibacterial agents selected in terms of chemistry, compatibility with polymer matrix, temperature stability, need for compatibiliser, mode of action and microbes targeted. It is important to note that the work in Work Packages 1 and 2 are interlinked. In order to evaluate antibacterial effect and the behaviour of the compound in terms of effect of biocide on polymer etc, compounds must be produced and analysed in accordance with WP2.

To evaluate compatibility of antibacterial agent and polymer different mixtures have been compounded using different antibacterial agent concentration and the base polymers PP or PET depending on the temperature behaviour, temperature resistance and chemistry of the biocide. The compounds are inspected in their behaviour during processing to detect any

degradation of the base polymer or other processing problems such as chemical reaction causing gases etc. Brittleness in resulting compound, discolouration etc can easily be spotted. The compounds are analysed by TGA to investigate possible changes in the polymer due to the addition of the antibacterial agent.

The work performed:

- Discussion on polymers for mixing with biocide, selection of grades
- Discussion on which biocide suits which polymer
- Collection of data on biocides under evaluation; toxicity, temperature resistance, molecular structure, prior experience of effect on bacteria etc.
- Compounding of PP/biocide or PET/biocide depending on temperature resistance
- Evaluation of compound quality by behaviour at processing
- Evaluation of compound by TGA

Task 1.2 - Deviations & Corrective Actions:

The work for Task 1.2 was done in time but just as for task 1.1 all work has not been completed as all biocides have not been accessed. The work in task 1.2 will continue in parallel with work in WP 2 and 3 in the next project period. This is not regarded as a big problem since important information is gathered by working in this way.

Task 1.2 – Use of resources

The work has been focused on the following:

TI:

- Meetings with Swerea for discussion on compounding of biocides, compounding into PET or PP, decision for each individual biocide
- Evaluation on possible degradation biproducts – health effects, toxicity, damage to machinery

- Meetings with Swerea in regard to compounding results
- Coordination of work

Swerea:

- Meetings with TI for discussion on compounding of biocides, compounding into PET or PP, decision for each individual biocide
- Evaluation on possible degradation biproducts – health effects, toxicity, damage to machinery
- Compounding of biocides with PET or PP
- TGA analysis on biocides and compounds
- Evaluation of compounds in regard to processability
- Production of plaques of compounds
- Meetings with TI in regard to compounding results

ITCF:

- TGA analysis of biocides
- Input to evalutation of suitable resin for individual biocides

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Norwex:

- Delivery of masterbatch for reference materials
- Delivery of cloths for reference

Task 1.3 Evaluate optimal polymer/antibacterial agent mixtures

Evaluate which microfibre component and what grade of that component is most suitable for mixing with antibacterial agent. Selection of the most suitable resin/resins for mixing. A program was set-up for initial trials to investigate possible differences in compatibility, dispersion, resulting quality etc.

Task 1.3 – Activity and Results in Reporting Period 1:

To evaluate optimal mixtures of antibacterial agent and polymer different mixtures have been compounded using different antibacterial agent concentration and the base polymers PP or PET depending on the temperature behaviour, temperature resistance and chemistry of the biocide. TI and Swerea have gone through the list of biocides and together made the decision on which resin they are to be compounded into, if there are any safety issues etc. The compounds are inspected in their behaviour during processing to detect any degradation of the base polymer or other processing problems such as chemical reaction causing gases etc. From the compounded materials, plaques are pressed for testing of antibacterial effect.

To analyse the compounded biocide/polymer mixtures several analytical methods have been used. TGA, Thermogravimetric analysis, is applied in order to determine the weight loss of a sample when exposed to heat, this has been used to establish the decomposition of the biocides before compounding. SEM/EDX characterisation has been used for investigating the biocide distribution in the plaques. In addition, the molecular weight and molecular weight distribution has been determined by SEC/GPC. A Dynamic Stress Rheometer has been used to determine the rheological properties of the molten samples.

The compounding trials at Swerea have given a good indication on the effect of the biocide on the resin into which it has been compounded. TGA has been used for evaluating the effect of the biocide on the polymer. In addition colour and possible brittleness of the resulting compound has been recorded.

The results of task 1.3 are detailed in D 1.2.

Task 1.3 - Deviations & Corrective Actions:

The work in task 1.3 is just as task 1.1 and 1.2 delayed for the exact same reason, all biocides that the project would like to investigate have not been sourced. However, as described earlier we do not foresee problems due to this issue as the work will be pushed forward more quickly due to the experiences gathered during the work with the first biocides. Centexbel time has

been redistributed from WP1 to WP2 as the antibacterial testing is very labour intensive and much of the work is done by hand.

Task 1.3 – Use of resources

The work has been focused on the following:

TI:

- Discussion with Swerea on results and processing issues
- Discussions on concentration for plaques, production method for plaques
- Contacts with biocide suppliers when necessary
- Coordination of work
- PET versus PP, discussions with Norwex on process

Swerea:

- Discussion with Swerea on results and processing issues
- Discussions on concentration for plaques, production method for plaques

Centexbel:

- Discussion with TI and Swerea on testing methods
- Modification of the ISO 22196 in comparison with ISO 20273. The ISO 22196 is the Film Contact Method for plastics and the ISO 20273 the method used for assessing the reference Norwex cloth. These should later be comparable.
- Modification of bacterial suspension, inoculum concentration, presence of nutrients in the inoculum
- Initial testing on plaques using the film contact method

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 1.4 Health, safety and standards

Health, safety and standards. TI will evaluate health, environment and safety in regard to antibacterial agents of interest.

Task 1.4 – Activity and Results in Reporting Period 1:

For all biocides on the list of selected agents all possible information has been gathered; chemistry, hazard classification, temperature resistance, MSDS, references in literature in regard to previous use as biocide. The decomposition temperature was measured by TGA, this value is important not only to know that the biocide withstands the processing temperature but also to know if there will be any bi-products while processing that may be hazardous for the personnel handling the compounding. In all cases an evaluation of the substance during processing has been made and in cases where there has been uncertainty in regard to compounding into PET requiring a high temperature, the substance has instead been compounded into PP. As no substances in product type 2 or 4 have been approved according to the Biocidal Products Directive, the substances have also been evaluated by a TI toxicologist so that the project does not proceed with any substance that is unlikely to reach approval at a later stage.

The development in regard to the Biocidal Products Directive has been followed via http://ec.europa.eu/environment/biocides/index.htm where e.g. non-inclusion documents are being issued. The project has also been in contact with the Swedish Chemicals Agency in regard to investigate the possibility, time required and cost for placing a substance for review.

Task 1.4 - Deviations & Corrective Actions:

No deviations

Task 1.4 – Use of resources

As task 1.4 is a summary task to stress the importance of the health and safety issues when performing the work in Cleancloth the work performed here is very much in connection with the work described in earlier tasks. Therefore little time has been put down in this summary for task 1.4. The work has been focused on the following:

TI:

- Research into the Biocidal products directive
- Set up of main list of biocides in the correct product type and not on any non-inclusion document
- Literature study and database searches for chemical composition, physical properties, toxicity classification, prior use as biocide, any known biocidal action, suppliers and set up of a datafile with all biocides inclusing all known information on these
- Collection of MSDS
- Evaluation of substances on the list in regard to applicability in Cleancloth
- Resource towards Swerea for questions on toxicity and handling
- Evaluation of the substances in regard to possible hazards to personnel as well as equipment during compounding

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

WorkPackage 2: Production of master batch and evaluation and choice of antibacterial agent.

WP 2 - Objectives:

Compound antibacterial agent and PA/PP/PET to find optimal matrix for the agent. Produce compounds containing the selected antibacterial agents and test these for antibacterial activity, material quality and compatibility. By aid of the results received in WP1, choose five antibacterial agents that will be taken into larger scale microfibre production. Initial tests are performed to find the concentration of antibacterial agent needed for full effect. Make all necessary calculations to enable production of antibacterial agent master batch. Produce microfibre containing the antibacterial agents and commence with testing of antibacterial effect as well as physical properties

Results from work in WP1 are used for choosing the 5 most promising antibacterial agents. Compounding of PP/antibacterial agent and PET/antibacterial agent is performed to investigate possible differences in compatibility, dispersion, resulting quality etc. Initially, PA/antibacterial agent was an intended combination but it has been excluded due to a high processing temperature in combination with lower content in volume in the microfiber structure. Compounds of the selected antibacterial agents with the chosen matrix will be produced and tested for antibacterial effect, time for desired effect, resulting material quality and compatibility. Masterbatch is produced from each of the 5 agents with the corresponding most suitable matrix. Calculations are made for each agent on the required concentration. The concentration and cost of agent are important parameters in choosing the most suitable antibacterial agent. Microfibre is produced on the laboratory scale extrusion equipment and the resulting microfibre is tested for antibacterial effect and physical properties.

Task 2.1 Choice of the 5 most suitable agents and production of masterbatch alternatives

Choice of the five most suitable antibacterial agents and production of master batch alternatives. Norwex will participate in the evaluation of suitable agents with special focus on cost versus effect. TI will choose the three material combinations that have the best combination of properties based on the analysis and production in WP2, and set-up a cost-to-concentration scale to compare agents. ITCF will produce microfibre for testing. CenTexBel will perform testing of the antibacterial effect of produced fibre and choose the three most suitable. Swerea will participate in the production of master batch with different concentration of antibacterial agents.

Task 2.1 – Activity and Results in Reporting Period 1:

Centexbel is the task leader of this task. The compounded antibacterial agent/polymer materials were analysed at Centexbel using two methods, the Film Contact method and the Absorption method. The Film Contact method is used on textile samples whereas the Absorption method is used on pressed plaques. These two methods are correlated to eachother by producing plaques and textile from the same material and comparing test results, this is important in order to show whether the plaque tests can be used as a good indication on the antibacterial effect of an agent in fiber.

The results from the bacteria testing are compared with observations from the compounding procedure and the results from TGA analyses on agents and compounded materials. The objective is to try to understand the bacteria test results and their connection to the agents and production of each compound. If the bacteria tests for a certain agent show that it is effective it is desirable to understand why and to find out if any modifications can be done to maintain

or improve the positive result even further. It is for instance desirable to lower the antibacterial agent content but to still keep a sufficient antibacterial effect.

As an example of the approach described above, one can compare the results retrieved so far for the antibacterial agent no 10, Biphenyl-2-ol. The antibacterial test results show that this agent has no antibacterial effect when compounded into PET but has a very strong effect when compounded into PP. When studying the TGA curve of the agent itself it is clear that it is almost completely decomposed at the processing temperature for PET while a much larger amount, approximately 40%, is still present at the processing temperature for PP. Obviously the agent has to still be present in a compound to be able to have an antibacterial effect. Observations from punching the compounds indicate that the PET polymer has been affected more of the agent or its decomposition products than the PP compound. TGA analyses of the compounds do not differ much in weight loss at respective processing temperature as most decomposition or degrading has already occurred during the processing procedure.

At this time results for some of the analysed biocides are very promising. In PET, which is the preferred polymer for carrying the biocide, Agent A and Copper sulphate have proven extremely efficient with complete or almost complete destruction of bacteria at 3 h testing time. In PP, nonanoic acid, Cinnamaldehyde, Biphenyl-2-ol, agent B, oligo(2-(2-athoxy)ethoxyethylguanidinium chloride), 5-chloro-2-(4-chlorophenoxy)phenol and poly(hexamethylenebiguanide)hydrochloride have all been found efficient at 3 hours. The efficiency at even shorter times will be analysed but it is then preferable to do these tests on textile samples.

The work performed in this task is detailed under deliverable 1.2 and 2.1

Task 2.1 - Deviations & Corrective Actions:

As all biocides of interest have not been evaluated due to the problems with sourcing described earlier, the work in task 2.1 is also delayed as the remaining biocides not yet in-house must also be taken into account. The coordinator, Norwex, has decided to synthesise a selected number of the missing substances outside of the project budget. Prior to the decision on synthesis, TI contacted Sigma-Aldrich to investigate their price for synthesis, it was evident that the best option would be to have the synthesis done at PP Polymer and a literature study on the substances and possible routes for synthesis has been initiated. Via Sigma-Aldrich an extensive database search was performed free of charge. This helped make sure that no mistakes have been made in the sourcing attempts, the substances not found are not available. The synthesis will, as stated, be performed by consortium partner PP Polymer. As soon as a substance is at hand compounding and analysis will commence.

Task 2.1 – Use of resources

Here it should be noted that in the work presented by Centexbel in deliverable 2.1, some work that technically belongs to reporting period 2, that is performed after 31082010 is included. However, in the reported time for Centexbel, only work in period 1 is considered.

The work has been focused on the following:

TI:

- Evaluation of results from processing
- Evaluation of results from antibacterial testing
- Contacts with all RTDs
- Coordination of work
- Discussions with RTDs
- Selection of biocides for fiber spinning
- Contact with Coordinator on progress

Swerea:

- Production and supply of more material for test when needed
- Evaluation of test results together with TI
- Production of plaques and bags for laundry-test
- Performing washing according to decision taken in consent between RTDs

ITCF:

- SEM/EDX Characterisation of biocide distribution
- Determination of molecular weight and molecular weight distribution by SEC/GPC

- Rheological characterisation of modified polymer/additive samples
- Discussion on test results

Norwex:

- Follow up on technical work performed by the RTDs
- Participation in discussions on particle size and possibilities in varying the fiber diameter

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 2.2 Calculations of required concentration in microfiber. Produce microfiber on lab scale

Make calculations of required concentration in microfibre and produce microfibre. TI will make the specification for master batch production, and together with Norwex set up specification for microfibre production based on results in task 2.1. According to TI specification Polisilk will produce microfibre and PP Polymer produce antibacterial compound.

Task 2.2 – Activity and Results in Reporting Period 1:

This task has not had an activity in the first period as the most promising antibacterial agents have yet not been selected. The testing performed in earlier tasks has been performed using the concentrations 5 and 10% by weight. This gives an indication on effect but analysis on fiber material is needed as well as analysis of the effect with the agents added with the correct particle size. In the resulting microfiber material the particles should be in the size of 400-500 nm. For the initial tests on antibacterial efficiency this is not the size that is used since it is not readily accessible. Work has been initiated in regard to decreasing the particle size to the desired range. One of the biocides was selected for trials, grinding in 99.5% ethanol for 6 days and using a 20 micron mesh was attempted. Grinding in cyclohexane for 4 days was also attempted.

The work performed in this task is detailed under deliverable 2.2

Task 2.2 - Deviations & Corrective Actions:

As all biocides of interest have not been evaluated due to the problems with sourcing described earlier, the work in task 2.1 is also delayed as the remaining biocides not yet in-house must also be taken into account. The coordinator, Norwex, has decided to synthesise a selected number of the missing substances outside of the project budget. The synthesis will most likely be performed by consortium partner PP Polymer. AS soon as a substance is at hand compounding and analysis will commence.

Task 2.2 – Use of resources

No resources have been used at this time.

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 2.3 Testing of microfiber antibacterial and physical properties

Testing of microfibre antibacterial and physical properties. Evaluation of results. Swerea will perform testing of antibacterial compound physical properties, whereas ITCF will test the microfibre physical properties. Microfibre antibacterial properties will be tested by CentexBel and they will evaluate the results from themselves and ITCF.

Task 2.3 – Activity and Results in Reporting Period 1:

This task has had some activity in the first period. The work with producing microfiber has begun and the first microfiber produced will be used for correlating the tests performed on plaques with tests on textile. There is an issue of particle size that needs to be solved and by the end of the project period work was initiated to reduce the particle size of two biocides to the desired 400-500 nm range. Meanwhile, fiber will, in the beginning of period 2, be produced from biocides with a smaller particle size (<160 nm) in order to correlate test methods and evaluate processability as well as get an indication on the effect of the biocide in an actual textile as the selected biocide has shown extremely promising results on plaque.

The work performed in this task is detailed under deliverable 2.2

Task 2.3 - Deviations & Corrective Actions:

As all biocides of interest have not been evaluated due to the problems with sourcing described earlier, the work in task 2.2 is also delayed as the remaining biocides not yet in-house must also be taken into account. The coordinator, Norwex, has decided to synthesise a selected number of the missing substances outside of the project budget. The synthesis will most likely be performed by consortium partner PP Polymer. As soon as a substance is at hand compounding, fibre production and analysis will commence.

Task 2.3 – Use of resources

ITCF:

- Initial trials with production of fiber from antibacterial compound

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

WorkPackage 3: Knitting of selected microfiber into cloth and testing of antibacterial properties

WP3 - Objectives:

The testing of antibacterial fibre in WP3 gives a good indication of antibacterial effect; further testing on cloth material is necessary to make the final choice. Cloth material is produced from all material combinations produced in WP3. Testing of antibacterial efficiency is performed together with testing of physical properties of the resulting textile material. The antibacterial effect and physical properties together will be the basis of the final choice of antibacterial agent for CleanCloth. Production of 500 cloths for end-user validation.

Throughout WP 3 work has been coordinated by Teknologisk Institutt working closely with Swerea, ITCF and Centexbel on sample production and testing of antibacterial effect as well

as how and where to split fiber chemically, since beneficiary Polisilk only work with mechanical splitting (which works for PA/PP but not for PA/PET). In addition work has been performed on modification of Agent A (ITCF) to facilitate addition and dispersion in PET. Microfiber was produced at Swerea after investment in a custom-made nozzle producing microfiber close in specification to the desired fiber. Fiber, although not microfiber, was also produced at ITCF closely evaluating the effect of different Agent As on fiber properties and dispersion.

Under WP 3 work was done in regard to:

- Dispersion of particles in the base polymer
- Routes to distribute antibacterial agent in PET
- Grinding of biocide powder to smaller size
- Use of modified Agent A from BYK Altana to aid distribution
- A new modified Agent A produced by BYK Altana using Agent A delivered from Cleancloth consortium
- Specification of custom-made nozzle for the fiber spinning equipment at Swerea
- Work on fiber spinning with both PP/PA and PA/PET fiber with corresponding biocide
- Characterisation of resulting fiber, physical and mechanical
- Knitting into simple textile material for analysis
- Trials on chemical splitting of PA/PET
- Mechanical splitting of PP/PA fiber at Polisilk
- Evaluation of antibacterial effect
- Large scale fiber production
- Knitting into prototype cloths at Engtex/Hoffmann GmbH via ITCF
- Cutting and sewing of cloth material into cloths for futher testing
- Post treatment of cloths, i.e. splitting

Task 3.1 Large scale microfiber production for knitting

Large scale production of microfiber for knitting. Polisilk will produce microfiber with the assistance of ITCF's processing optimisation. ITCF will transfer knowledge and experience from extrusion trials to Polisilk

Task 3.1 – Activity and Results in Reporting Period 2:

Different grinding methods were tried and evaluated at Swerea IVF. As the grinded particles were prone to forming agglomerates, it was decided to work with a commercially available 160 nm Agent A. In addition, a modified Agent A from BYK Altana and a custom-made modified Agent A were used. Work focussed on two compounds, PA/PET/Agent A and PP/PA/Agent B.

The PET masterbatches were produced at Swerea IVF. The screw configuration was set up to give a high degree of mixing and kneading and is typical for filler or nano-particle incorporation. Different positions for adding (main inlet or at various positions to melt) were evaluated by studying the dispersion with the LOM method. The PET masterbatches with Agent A from BYK stabilized pastes were produced in the same way as the ones from powders with the exception that the ABA (BYK pastes) is manually fed by syringes to the main inlet of the compounding extruder, parallel to the dried PET pellets feed.

Initial fiber spinning trials were performed at ITCF, characterizing the produced fiber. With this as background, fiber spinning with the new nozzle was started at Swerea. Trials with Agent A gave problems with gassing, causing breakage. At ITCF, trials adding Agent A at the polymerization of PET was performed. The work is detailed in D3.1. TI performed trials with chemical splitting of the PA/PET/Agent A fiber were performed at the Swedish School of Textiles in Borås, these splitting trials showed that the small scale equipment can be used for cloths produced in the project.

Trials were also carried out with PP/PA/Agent B. These trials produced good quality fiber, that was easily split by warm water.

Task 3.1 - Deviations & Corrective Actions:

Originally, fiber production was allocated to Polisilk. Discussions with Polisilk showed that a large volume of compound, 200 kg, would be needed to operate their equipment. In addition, Polisilk had their production line booked, making it very expensive for them to hold their production for Cleancloth. Considering the cost of biocide as well as cost for resin, this was not an operable option. Discussions between TI, Norwex and Swerea concluded that it would

be possible to produce low quantities of microfiber at Swerea. Therefore, Swerea in dialogue with TI and Norwex, ordered a custom made nozzle for their small scale equipment, enabling production of fiber. In regard to production of masterbatch, the reallocation of the work to Swerea also meant that this work was not performed at PP Polymer. This was natural as the production was an iterative process where compounding was done one day followed by fiber spinning the next day. PP Polymer was in this process as a supportive partner in terms of cleanness of process. PP Polymer performed other work in period 1 of the project, relating to ways to synthesize biocides that could not be sourced.

Task 3.1 – Use of resources

TI:

- Coordination of work between all parties
- Discussion with coordinator on fiber quality, nozzle production
- Meetings with Swerea on fiber spinning and compounding
- Chemical splitting, including initial trials

Swerea:

- Preparations of antibacterial agents
- Optimization of compounding processes
- Development of compounding efficiency evaluation method
- Production of masterbatches
- Trial bicomponent melt spinning experiments
- Microfiber melt spinning production
- Performing washing and leaching cycles
- Performing chemical analyses
- Developing, performing and evaluating splitting alternatives (PP)
- SEM analysis of produced fibers and cloths

ITCF:

- Initial work on fiber spinning
- Work on particle dispersion
- Contact with BYK Altana

Norwex:

- Detailing for nozzle production
- Involved in results of fiberspinning
- Analysis of fiber at laboratory

Task 3.2 Production of cloth from all materials

Production of cloth from all materials in WP3. EngTex as will produce the cloth according to Norwex specification, and ITCF will transfer knowledge and experience from extrusion trials to EngTex as.

Task 3.2 – Activity and Results in Reporting Period 2:

Work concentrating on production of cloth as close as possible to a standard cloth in geometry, loop configuration, size and post-treatment. Prototype 1 based on PP/PA was produced at Engtex AB, whereas Prototype 2 based on PA/PET was produced at ITCF/Hoffman GmbH. The textile was cut and sewn at Syverket in Borås, Sweden and posttreated. In the case of the chemical splitting for PA/PET, this was done at The Swedish School of Textiles in Borås.

Task 3.2 - Deviations & Corrective Actions:

Prototype 2 could not be produced at Engtex as their machinery could not handle the yarn for that prototype. The alternative was then to have the material produced at Hofmann GmbH in Germany, with personnel from ITCF.

Task 3.2 – Use of resources

The work has been focused on the following:

TI:

- Coordinating work on cloth production, discussions with Engtex, Norwex and ITCF on cloth production
- Locating site for cutting and sewing of textile into cloth
- In charge of post-treatment, all contact with post-treatment sites
- Discussions with ITCF on knitting of prototype 2

ITCF:

- Working with Hofmann GmbH on production of textile for prototype 2
- Working with Hofmann during production

Norwex:

- Delivery of fiber for prototype 2
- Specification of required set-up to Engtex

Engtex:

- Production of prototype 1

Task 3.3 Testing of antibacterial efficiency and mechanical properties of cloth

Testing of antibacterial efficiency and mechanical properties of cloth. TI will perform mechanical testing on the cloth, whereas CenTexBel will test antibacterial effect.

Task 3.3 – Activity and Results in Reporting Period 2:

The focus of task 3.3 is the evaluation of the properties of the final cloth. The work has been performed mainly by Centexbel using the Absoption method to evaluate the antibacterial effect of produced textile. The testing has been performed on the bacteria strands Escherichia coli and Staphylococcus aureus.

Good results were obtained with 1 % Agent A, and for this reason a smaller concentration (0.5%) was also tested. The PET knitted fabrics treated with 0.5% and 1% Agent A (ABA18B=ABA38) both have an effect against both strains after 20 hours. No effect is observed after 0.5 and 3 hours for the 0.5% Agent A. The concentration of 1 % is necessary to have the required effect after 3 hours.

Since good results were obtained with the Agent A38 1 %, the washing effect was studied. Unfortunately, after washing (with or without detergent), the effect of the Agent A ABA 38 disappeared.

• Another 100 % PET knitted fabric was produced by ITCF, incorporating 1% nano Agent A (ABA18A=ABA29).

The antibacterial effect obtained was

- very strong towards Escherichia coli (but less important towards Staphylococcus aureus)
- after 3 hours and 20 hours of contact time.

No effect is observed after 0.5 hour and, again the results were very heterogeneous indicating an uneven distribution of Agent A on the surface fiber.

• Because of the very significant antibacterial effect of a 2 denier, Agent A containing fiber it was decided to try out a combination textile by mixing standard microfiber with 2

denier, antibacterial fiber. By placing the biocide in a coarser fiber, the hope was also to reduce the effect of washing/post-treatment.

Compared to the untreated Norwex reference cloth the received PET/PA combination fiber has a slight antibacterial effect after 3 hours against both strains of bacteria. After 20 hours the effect is still there with Staphylococcus aureus but less important for Escherichia coli.

Technically it is important to increase the concentration of Agent A in order to have the strong antibacterial effect after 3 hours.

- In PP knitted fabric work focused on Agent B, but Agent A was evaluated

- 100 % PP knitted fabric, 1% nano Agent A (ABA18A=ABA29)

- strong towards both strains after 20 hours
- after 3 hours, the effect is more important with Escherichia coli and weak with Staphylococcus aureus

As it was found with the PET trials, individual results were very heterogeneous indicating probably an uneven distribution of Agent A on the surface of the PP yarns.

- PA/PP cloth produced by Engtex including 3 % Agent B.

Directly after production of the cloth the antibacterial effect was very strong after 3 hours and 20 hours, and those results are the same with both strains. Unfortunately, the effect disappears after washing.

The results are detailed in D 3.2.

Task 3.3 - Deviations & Corrective Actions:

The main deviation in task 3.3 is that the focus on mechanical testing was not as pronounced. The reason is that the prototypes are not comparable to a standard cloth as they are produced in single sided Terry and not double sided terry as the standard cloths. To compare the prototypes produced in the project to a standard cloth when they are not equivalent in set-up is not relevant. The standard microfiber cloths of PA/PET have been heat-set during production, the PA/PET in Cleancloth has not and a comparison of mechanical properties is not relevant. Touch and feel of the produced cloths indicate that they are definitely of satisfactory quality.

Task 3.3 – Use of resources

The work has been focused on the following:

TI:

- Coordination of work
- Decision on tests

Centexbel:

- Modification of the ISO 22196 in comparison with ISO 20273.
- Modification of bacterial suspension, inoculum concentration, presence of nutrients in the inoculum
- Antibacterial tests

WorkPackage 4: Testing of Cleancloth cleaning efficiency

WP4 - Objectives:

Since well defined and acknowledged standards in regard to cleaning efficiency are lacking, the CleanCloth is tested according to testing procedures developed at TI, cleaning efficiency on dust, friction, indulgence and cleaning efficiency on spots. Include testing on leaching of

antibacterial agent and reaction to mechanical influence such as laundry. Test results will be compared to results on similar products already in the TI database.

Work in WP4 has been performed by TI. The testing performed deals with the efficiency of the produced prototype cloths compared to standard microfiber cloths in a number of specific tests.

Under WP 4 work was done in regard to:

CleanCloth was tested according the TI procedures Cleaning efficiency on dust: cloth should raise the quality of cleaning from dust level 2 to dust level 5 in accordance with NS INSTA 800; Friction: use of TOPEKA friction measurement equipment, friction level 4. Indulgence: cloth must not subdue polyacrylate at 100 cycles in Erichsen Waschbarkeit- und Scheurprüfgerät modell 255; Cleaning efficiency on spots: Testing on a polyacrylate surface, spots from coffee, preserve and milk dried for 2-5 days. Wear resistance: assess the difference between fibre release from exposed (cloth used in the indulgence experiment) and unexposed cloths

Task 4.1 Test procedure specification

Test procedure specification. Norwex and TI will agree on testing to be performed, and TI will make test plan for testing of cleaning efficiency.

Task 4.1 – Activity and Results in Reporting Period 2:

In task 4.1, the CleanCloth testing in regard to cleaning efficiency was set up. Testing is to be performed according to the Nordic Eco-labelling of fabric cleaning products containing microfibres version 2.0 12 October 2010 – 31 December 2013.

- Removal of dust and dirt It must be demonstrated that a microfiber cloth removes at least 85% of dust and dirt. Measurement of degree of dust and dirt was performed with a Dust Detector in accordance with NS INSTA 800.
- Assessment of hygienic conditions It must be demonstrated that cloths and mops containing microfiber reduce the amount of micro-organisms by at least 85% for cloths in accordance with NS INSTA 800.

- Indulgence: Cloth must not subdue PMMA at 100 cycles in Erichsen Waschbarkeit- und Scheurprüfgerät modell 255

- Cleaning efficiency on spots: Testing on PMMA surface, spots from coffee, juice and milk dried for 2-5 days

- Absorption The absorption capacity of the microfiber textile shall be expressed as DAC (Demand absorption capacity) in g/g - minimum 2,50 g/g- in accordance with ISPO 9073 – 12:2002

- Friction: use of TOPEKA friction measurement equipment, Damp wiping (centrifuge-dry):max 14N.

- Dimensional changes in washing and drying: The fabric cleaning product containing microfibers must not change more than 6 % in dimension following washing and drying.

Task 4.1 - Deviations & Corrective Actions:

No deviation

Task 4.1 – Use of resources

The work has been focused on the following:

TI:

- Set up of cleaning tests to be performed

Task 4.2 Cleaning efficiency testing

Cleaning efficiency testing. TI will perform testing on cleaning efficiency, spots and dust; friction and indulgence. A test report will be produced comparing CleanCloth to similar products

Task 4.2 – Activity and Results in Reporting Period 2:

The testing of the cleaning efficiency of cloths has been performed using the following cloth types:

1. PP/PA/Agent B cloth, double with 2 diagonal sems, named A
2. PET/PA/Agent A cloth named C
3. Standard Norwex cloth named B1
4. Standard consumer cloth named B

Before testing all cloths were washed at 600C with commercial laundry detergent and tumbled dry for 10 cycles. The cloths were tested in a centrifuge-dry condition without the addition of cleaning agents, except when they were tested for absorption. Testing was performed in dry condition. Tree parallels of each cloth were tested

- Testing of prototype cloths and standard cloths according to the test scheme set up in task 4.1
- Evaluation of results

Looking at all aspects of cloth performance, prototype 2 recieves the best score.

Task 4.2 - Deviations & Corrective Actions:

No deviation

Task 4.2 – Use of resources

The work has been focused on the following:

TI:

- Performing tests on cleaning efficiency

- Evaluation of test results

WorkPackage 5: Industrial validation

WP5 - Objectives:

To test the CleanCloth technology in hotel environment and in professional cleaning. Validate that the technology created is capable of decontaminating surfaces according to the goals set up. This will be validated through taking samples before and after cleaning of selected areas and surfaces. Gather end-user rating and comments on the product performance. Test and verify that the CleanCloth system performs in line with project objectives. Deliver questionnaire to technology evaluators. Demonstration of test results to the project beneficiaries. Compile ratings and comments from end users. The testing will be supervised by the specialist environment on cleaning technology at TI, supervising cleaning tests and taking samples. After a period of testing the product, the different heads of cleaning staff at the sites participating in product validation will fill in the questionnaires.

Work in WP5 has been performed by TI and SAS.

Under WP 5 work was done in regard to:

Set up of questionnaire for end user evaluation. Decision on method for analysis of antibacterial activity before and after cleaning. Selection of measurement-equipment to be used. Set up of specification for trials at SAS.

Task 5.1 Testing of the Cleancloth system in hotel environment

Testing of the CleanCloth system in hotel environment. SAS will use the CleanCloth technology in regular hotel cleaning activities in different hotel environments, give feed-back on the product to Norwex and TI, and set up contact with other SAS Radisson hotels to try the product and answer a questionnaire. Norwex, TI and CenTexBel will educate and give input to end users regarding the best use of the product, the best practice for cleaning with microfibre products and the antibacterial effect of the CleanCloth

Task 5.1 – Activity and Results in Reporting Period 2:

The biological activity on the selected surfaces before and after cleaning was analysed using a portable Kikkoman Lumitester PD-20. With this mobile device up to 2000 measurements for hygiene control can be taken, stored and transferred to any PC-system. The test protocol and the specification for performing tests were detailed by TI and delivered to SAS Radisson on site together with all cloths to be tested, ATP equipment and training on the ATP equipment by educated TI-personnel. The Questionnaires where delivered to SAS and returned to TI after finalizing all tests on site.

Task 5.1 - Deviations & Corrective Actions:

No deviation

Task 5.1 – Use of resources

The work has been focused on the following:

TI:

- Set up of field trial protocol
- Set-up and production of questionnaire
- Overview on equipment for analysis of biological activity, choice of equipment
- Delivery of relevant material for trials to SAS
- Training on ATP equipment

SAS:

- Performing cleaning tests
- Measurement of biological activity according to training and protocol

Task 5.2 Report compiling and summarizing comments and ratings

Feed-back on CleanCloth product. Nowex will in cooperation with Nilfisk give input to set up a questionnaire. Through SAS the questionnaire will be delivered to key personnel in-house and at other SAS hotels trying out the cloth. Finally TI will compile results and evaluate in collaboration with Nilfisk.

Task 5.2 – Activity and Results in Reporting Period 2:

Work on compiling and evaluating data from the ATP measurements as well as summarizing the results from the Questionnaires gathered from SAS. The ATP measurements are given in D4.1 as well as in D5.2 as it in D4.1 is used in an evaluation of cloths taking into consideration all testing performed.

Task 5.2 - Deviations & Corrective Actions:

No deviation

Task 5.2 – Use of resources

The work has been focused on the following:

TI:

- Work on processing the data gathered from the ATP measurements as SAS as well as answeres to the Questionnaires

WorkPackage 6: Training

WP6 - Objectives:

Perform training of the participating end-users on the use of the technology developed in the project. The training will enable them to further train other members of the Radisson group.

Work also includes putting together training material and perform training of key personnel from the participating end-users

Work in WP6 has been performed by TI.

Under WP 6 work was done in regard to:

- Training material on Cleancloth
- Information on prototypes and their use to SAS Radisson personnel prior to end-user tests in WP5

Task 6.1 Training of end-user staff

Training of end-user staff. Nilfisk will host and in cooperation with SAS participate in a training workshop. All remaining participants will perform training of key personnel in named organisations.

Task 6.1 – Activity and Results in Reporting Period 2:

The work in task 6.1 has been to develop training material for Cleancloth and inform the staff of SAS Radisson of how the prototype has been made, and how it is used.

Task 6.1 - Deviations & Corrective Actions:

Large scale training of end-users has not been performed in this project, the training performed has been training SAS on the use of Cleancloth and special features of Cleancloth. As the efficiency of Cleancloth long-term is not determined and the prototype cloth is not heat-set and not the standard size, the large scale training was not desired by the Coordinator and not recommended in terms of market strategy.

Task 6.1 – Use of resources

TI:

- Set up of training material
- Discussions with Norwex on training sessions
- Information to SAS on site on use of Cleancloth

Norwex:

- Discussions with TI on training sessions

SAS:

- Taking part in instruction of use

WorkPackage 7: Innovation Related Activities

WP 7 - Objectives:

Project results formulated/compiled into a protectable form, including patents. Develop an Exploitation Strategy; a Consortium Agreement signed between the beneficiaries and protection of the Intellectual Property Rights arising from the technological developments in the project. Promotion of developed technology to at least 20 of the SMEs in the European cleaning industry through industrial contact networks, trade press and websites. Disseminating knowledge & benefits of the project developments & results at 5 conferences and workshop events with a target of 150 attendees. Demonstration and presentation of the concept at trade or sector specific events or exhibitions.

Task 7.1 Protection of IPR/foreground

Protection of IPR/foreground. Norwex will with the participation of TI carry out patent searches to assess the viability of a patent application, prepare patent applications and submit through a patent agent, and create a preliminary DUP at mid-term and a final version by the

end of the project. IPR ownership and exploitation agreements within the consortium and outside of the consortium in the form of potential licensee agreements will be created.

Task 7.1 – Activity and Results in Reporting Period 2:

Work has been initiated by Norwex having contacted lawers specialising in patenting giving them the background to shorten the way towards a patent application. A patent search has been carried out by TI; a conflicting patent regarding integration of biocide in fiber was found but it is still possible to concentrate the patent around the biocide. An exploitation strategy has been developed at Norwex. The work in task 7.1 is detailed in D7.1.

Task 7.1 - Deviations & Corrective Actions:

None

Task 7.1 – Use of resources

Norwex:

- Contact with UK Lawyer firm, patenting specialist
- Development of exploitation strategy

TI:

- Patent search
- Assisting Norwex with report

Task 7.2 Dissemination of knowledge

Dissemination of knowledge. Norwex will participate with input to publications and exhibitions, especially towards end-user communities. Further to perform printing and

distribution of the information to be disseminated. Norwex will be responsible for the content of information to be disseminated and controlling that the content is in accordance to protection schemes. All remaining participants will contribute with input to the publications and conference material. Furthermore SAS, Nilfisk, TI, CenTexBel, Swerea and ITCF will participate on exhibition stands to promote and facilitate dissemination.

Task 7.2 – Activity and Results in Reporting Period 2:

The project web page has been continuously updated. The Cleancloth project has been disseminated by partners Norwex, PP Polymer, Nilfisk, TI, Swerea and ITCF at various events, specified in D7.2. A handout, agreed on within the consortium, was produced by TI and handed out to all partners.

Task 7.2 - Deviations & Corrective Actions:

None

Task 7.2 – Use of resources

Norwex:

- Dissemination of project at various events.

PP Polymer:

- Dissemination of project at various events

Nilfisk:

- Dissemination of project at various events

TI:

- Production and distribution of dissemination material
- Updating the project website
- Dissemination of project at various events

Task 7.3 Exploitation

Norwex will with the participation of PPP, Polisilk and EngTex as identify market areas and perform feasibility studies.

Task 7.3 – Activity and Results in Reporting Period 2:

The exploitation plan has been set up by Norwex, Nilfisk and TI.

When the product had been refined, processing optimized in terms of dyeing, heat setting etc the exploitation strategy follows the below schedule starting from month 1 – decision point for commercialization.

Month 1-2:

- Final pricing confirmed and negotiations completed
- Final testing in China with new equipment to confirm quality of microfiber samples.
- Advisory Council/Focus groups with Consultants to confirm pricing and/or quality value add
- All regulatory claims confirmed for microfiber and personal care positioning
- Product positioning confirmed with campaign outlined for rollout/integrated into The REAL Clean campaign
- Final decision on personal care product timing

Month 3.5:

- New antibacterial agent ordered and production begins no later than August 1.THIS IS THE POINT OF NO RETURN.
- The REAL Clean Campaign launched at Conference
- Discontinued plan for current antibac products confirmed with logistics
- Begin prelaunch campaign with task force
- Develop media campaign to encompass video/social media/testimonials
- Finalize new microfiber rollout schedule for 2013
- Registration for personal care products in progress

Month 6-8:

- Road Show schedule confirmed for Feb/Mar/Apr
- Planning for global rollout for other global markets
- Registration for personal care products completed
- Develop testimonials for social media campaign

Month 9-11:

- Countdown in January to the new rollout
- Begin social media campaign to gain momentum for rollout
- Road Show in full swing
- Global market planning for 2013 Conference rollout
- Personal care product rollout – To Be Decided (TBD) based on regulatory compliance registration

Month 12-14:

- Annual Conference promotions and launch
- Personal care product focus (TBD)
- Online training campaign through newsletters and webinars
- Global market planning for 2013 rollout

Month 15-17:

- Global Launch of worldwide
- Training workshops – with personal care focus
- Testimonials as part of the rollout
- New antibacterial microfiber products – TBD

Task 7.3 - Deviations & Corrective Actions:

None

Task 7.3 – Use of resources

Norwex:

- Set up of exploitation plan.

Nilfisk:

- Set-up of exploitation paln

TI:

- Set-up of exploitation plan

WorkPackage 8: Demonstration

WP 8 - Objectives:

Demonstrate the product and its benefits and areas for use to target groups. Existing Nilfisk customers and Norwex sales agents and other interested parties.

Set up demonstration presentation and material. Invite target persons and groups. Demonstrate results of testing and benefits of the product.

Task 8.1 Demonstration sessions

Demonstration sessions. Norwex will provide input to demonstration material and set up, and in collaboration with SAS and Nilfisk invite target groups. TI will contribute with demonstration presentation.

Task 8.1 – Activity and Results in Reporting Period 2:

It is the desire of the Coordinator, who would have their name on the product, not to conduct demonstration sessions at this point. From a strategic market viewpoint, it is not a wise decision to demonstrate a product that has not been optimised and evaluated enough to know if and when it will hit the market. The contacts Norwex has on the market are well aware of the ongoing project and its aim and objectives. The outcome of the last evaluations of the prototype cloths were not available until late in the project and therefore the decision not to do demonstration sessions were not communicated at an earlier stage. More resources were needed for completion of the prototypes than foreseen.

Task 8.1 - Deviations & Corrective Actions:

As stated above, demonstration sessions has not been conducted for the following reasons:

It is the desire of the Coordinator, who would have their name on the product, not to conduct demonstration sessions at this point. From a strategic market viewpoint, it is not a wise decision to demonstrate a product that has not been optimised and evaluated enough to know if and when it will hit the market. The contacts Norwex has on the market are well aware of the ongoing project and its aim and objectives. The outcome of the last evaluations of the prototype cloths were not available until late in the project and therefore the decision not to do demonstration sessions were not communicated at an earlier stage. More resources were needed for completion of the prototypes than foreseen.

Task 8.1 – Use of resources

No resources used, resources for WP8 moved to WP 3, 4 and 5

WorkPackage 9: Consortium Management

WP 9 - Objectives:

The efficient and effective management of the technical work program to ensure the objectives of the project are realized.

A framework for effective project delivery will be established. The project progress will be monitored at quarterly management meetings by the "project board" to include a representative from each beneficiary. In addition the social and economic impact will be monitored and the status discussed at the quarterly board meetings.

Monitoring of all technical tasks to ensure the interests of the end-user community are maintained. Measurement of the project technical progress against the economic objectives. Measurement of the project against the societal objectives. Review technical progress against plan at 3 monthly intervals. Discuss technical issues and update as necessary.

Effective communication between all consortium members. Bi-monthly progress bulletins issued by task leader containing review of technical progress in the preceding period and plans for the coming period. Highlight any technical issues and positive technical results. Provide early warning of project milestones.

Task 9.1 Review and management of project progress versus objectives

Review and management of project progress versus objectives. Norwex will review project progress against the economic, industrial and operational objectives and targets with the background as concept generator, and ensure that the scientific and technological goals will be achieved with regard to industrial, economical and market goals set out in the project.

Task 9.1 – Activity and Results in Reporting Period 2:

Norwex has been extremely active in the project taking part of all strategic decisions and monitoring progress in all areas. Skype meetings between Norwex and TI frequently, in addition Norwex and TI have been using MS Project for overview on details of work, including responsible party, dependencies between subtasks, start and finish, latest finishing date etc. Ti have had frequent contact with all other RTDs to coordinate work. Norwex have controlled work progress by updates via email, MS Project file or Skype conference. The project has been using basecamp (internal website) for sharing messages, documents and presentations between partners.

Task 9.1 - Deviations & Corrective Actions:

None

Task 9.1 – Use of resources

The work performed has focused on:

Norwex:

- Close follow up on technical work performed by the RTDs
- Skype meetings
- Meetings with RTDs
- Meetings with TI

TI:

- Skype meetings with Norwex
- Arranging RTD meetings
- Arranging management and technical meetings
- Detailing the work in MS Project
- Set-up and management of the project website as well as basecamp for internal exchange of information and project documents

All SMEs:

- Participation in project meetings and input on work performed.

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 9.2 Technical management and progress

Technical management and progress. Norwex will together with TI be in charge of monitoring of all technical tasks and review technical progress against plan at 3 monthly intervals.

Task 9.2 – Activity and Results in Reporting Period 2:

Technical meetings have been held and the progress of technical work have been communicated via basecamp, email and meetings. Plan for use and dissermination of foreground.

Task 9.2 - Deviations & Corrective Actions:

None

Task 9.2 – Use of resources

The work performed has focused on:

Norwex:

- Close follow up on technical work performed by the RTDs
- Work on plan for Use and Dissemination of foreground

TI:

- Work on plan for Use and Dissemination of foreground

All SMEs:

- Participation in project meetings and input on work performed.

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 9.3 Consortium communication

Consortium communication. Norwex will be in charge of communicating results from WPs and tasks with the participation of all remaining participants.

Task 9.3 – Activity and Results in Reporting Period 1:

The project has used the internal website via Basecamp to share reports, presentations etc.

Task 9.3 - Deviations & Corrective Actions:

None

Task 9.3 – Use of resources

The work performed has focused on:

Norwex:

- Close follow up on technical work performed by the RTDs

TI:

- Set up of basecamp for internal sharing of presentations, project documents, presentations etc
- Distribution of passwords for basecamp to all project beneficiaries

All SMEs:

- Participation in project meetings and input on work performed. All participants have access to basecamp where the reports and presentations at meetings etc are stored.

For further details on the number of manmonths spent on each task by each partner, this information is found in section 6

Task 9.4 Administrative management of the consortium and the consortium agreement

Administrative management of the consortium and the consortium agreement. Norwex will be handling the project management in an efficient and effective manner and ensure the objectives of the project to be realized.

Task 9.4 – Activity and Results in Reporting Period 2:

Contract amendment was issued and approved. All actions taken for the final reporting. Arrangement of management meetings. Distribution of funds from the second payment.

Task 9.4 - Deviations & Corrective Actions:

None

Task 9.4 – Use of resources

The work performed has focused on:

Norwex:

- Distribution of funds, second payment.
- Contract amendment

TI:

- Contract amendment

All SMEs:

- Attending management meetings

Potential Impact:

Pathogenic and potentially pathogenic species are regularly introduced as microbial contamination into the home and public places such as hospitals, day care centres, offices and hotels. Wet sites, such as kitchen areas, toilets and bathrooms are most commonly associated with heavy contamination and potentially harmful species. However, other wet sites such as dishcloths and cleaning utensils have also been found to be heavily contaminated , , . The sink, waste trap and surrounding areas can also act as semi-permanent sources or reservoirs of bacteria. Gram negative species such as E. Coli, klebsiella spp. and pseudomonads have been shown to grow to substantial numbers in sink U-tube and toilet water, as well as in contaminated wet cloths. Additionally, potentially harmful organisms are quite often isolated from hand and food contact surfaces in the bathroom and toilet as well as in the kitchen . The reservoir/disseminator sites such as wet cloths and cleaning utensils have a high risk of germs being present, a constant risk for spread of germs and are always in need for adequate hygiene procedures.

Studies show that there is annually reported about 24 million cases reported of illness due to microbial contamination in the EU population of approximately 710 million inhabitants giving an incidence rate of approximately 3500 cases per 100.000 inhabitants , .

In Europe, of the reported cases of illness due to microbial contamination, more than 800.000 resulted in consultancy in the emergency department of an hospital, approximately 170.000 were hospitalised and 6.500 deaths are reported annually. Food contamination creates an enormous social and economic strain on societies. The possibility of reducing absence from work and hospitalisation due to hygiene related sickness would have a great positive impact on the economy, both considering the savings achieved in the companies experiencing absence of employees due to sickness but also savings achieved by reduced hospitalisation frequency. Social impact studies demonstrate that disease due to microbial contamination directly cause approximately 14.000 man-years being lost in Europe annually, representing an estimated cost of more than 50 Billion Euro in medical costs and lost productivity. Reduction of Cleaning Chemicals

Approximately 14.000 kg of household chemicals are released every day, representing an annual discharge of more than 5 million tonnes . Many of these products contain toxic substances that are not properly processed by sewage treatment plants and septic systems. Reducing the use of cleaning chemicals used while still achieving a good cleaning effect has a great positive impact on both environment and health. Environmentally Preferable Purchasing and Green Cleaning are becoming increasingly more important topics. Efficient cleaning is necessary to achieve a good indoor environment. However, some cleaning agents used contain harmful chemicals that endanger human health as well as contaminate the environment. Implementing green cleaning means using alternative products and using them correctly.

However, good hygiene practices such as using antibacterial CleanCloth before, during, and after food preparation can reduce the chances of contracting an illness due to microbial contamination, and the development of an intrinsically antibacterial, durable cleaning cloth with long lifetime will contribute to increased health in the home as well as in public environment. Afurther, absence due to hygiene induced sickness will be reduced leading to savings for companies as well as for society. The positive effects also extend to the outdoor environment as the use of chemicals in cleaning can be reduced; this also affects the working environment for cleaning personnel in a positive way.

As the coordinator wishes that the results of the work performed be kept highly confidential, the dissemination of the work performed in the Cleancloth project has been kept without detail. In the industry, and especially for cleaning product and microfiber, letting go of to much information can be involved with high risk, as the technology can then be picked up by e.g. Chinese factories producing similar products and dumping prices. TI has produced a leaflet/handout for the project beneficiaries with information on the project. This was forwarded to all partners and can be found in section 3.

Norwex AS

Mr Björn Nicolaisen has been mentioning the project in several of his Norwex conference speeches – which have been attended by between 300 and 800 persons. These events were:

- Conference in Edmonton, Canada, August 21 – 22, 2010
- Conference in Winnipeg, Canada, August 19 - 20, 2011
- Conference in Minneapolis, USA, August 16 – 27, 2011.

Also, the project was mentioned in his speech for the Norwegian conference September 3, 2011 with about 60 participants. Cleancloth was further mentioned during his speech in September 10, 2011 in the Baltic conference in Estonia with about 110 participants.

Norwex' manager in Australia, Paula Morris, has mentioned the project on several occasions in Australia:

She has mentioned the CleanCloth EU funded project and pointed to the link on their website at the Discover Norwex Presentations.

The dates were:

- 7/2/2011 Adelaide
- 30/3/2011 Melbourne
- 31/3/2011 Tasmania
- 2/4/2011 Newcastle
- 14/6/2011 Brisbane
- 3/8/2011 Brisbane

These meetings were specifically for people to find out more about Norwex and the business

PP Polymer

PP Polymer have been active in informin about the project and their role.

PP polymer attended the following:

- Antec, USA May 2010
- Biocide conference in Berlin, October 2010
- Cleantech Inn, Gothenburg, March 2012

In addition, PP Polymer has informed in their newsletter about the Cleancloth project at 3-4 occassions during the project lifetime. The newsletter reaches 1500 recipients involved in polymer industry, the newsletter goes out to the Nordic countries.

Nilfisk

CleanCloth beneficiary Nilfisk was/will be represented at the following conferences and fairs where material on the CleanCloth project will be available:

- Finclean, 26-28 October 2011, Tampere, Finland
- The SRTF Fair in Stockholm Sweden, 16-17 November 2011
- The SRTF Fair in Kristianstad, Sweden, 18-19 April 2012
- Cleaning and Hygiene fair, Gothenburg, 14-15 September 2011
- Cleaning and Hygiene fair, Stockholm, November 2011

TI

TI has been in charge of the project website including set-up and updates. TI also produced the dissemination material for the partners to use.

- Oslo Høyskole, Akershus Høyskole February 2012
- Annual NRTF meeting March 2012
- ISSA Interclean, Amsterdam 8-11May 2012

Swerea

Presentation held for the Chemicals Group at Swerea IVF. This group consists of 60-70 people from the textiles and electronics sectors. This group has more than 50 member companies, the majority in textiles.

- Presentation held March 27 2012

ITCF

ITCF have been involved in the following dissemination activities:

2012-01-10 Seminar on "Fibre structure – properties relationship" held at Oerlikon Barmag, Chemnitz, Germany

2011-07-01 Promotion at "Zukunftskonferenz Textil 2020", Haus der Wirtschaft, Stuttgart, Germany

2011-06-22 "Anti-bacterial agents as fibre additives", discussion with representative of Groz-Beckert GmbH, Albstadt, Germany

2011-05-26 Promotion at "Techtextil" at Messe Frankfurt, Frankfurt, Germany

2011-04-27 Promotion at TWD Fibres, Deggendorf, Germany

2010-11-11 Lecture on "Fibre spinning and properties", University Stuttgart, Stuttgart, Germany

2010-05-19 Discussion with additive producer BYK-ALTANA, Wesel, Germany

2009-12-10 Discussion at Luxilon, Antwerp, Belgium

In regard to exploitation of results, an exploitation plan has been set-up, with a plan for the launch of a new product. However, more work is required before this is a reality.

List of Websites:

For further information on the project, please visit our homepage www.cleanclothproject.com or contact:

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