MISTRA TERRACLEAN

ANNUAL REPORT 2017

ABOUT MISTRA TERRACLEAN

With a vision to address global sustainability challenges, the Mistra TerraClean program will use naturally occurring and commercially important raw materials indigenous to Sweden, such as (nano)cellulose and mesoporous inorganic materials invented and developed in Sweden, to develop smart materials for removal of chemical wastes and pollutants from ambient water and air in the environment and industrial effluents. The program will integrate strong research and innovation environments in the Stockholm-Uppsala region to a national hub capable to provide expertise required to set necessary momentum and advance smart materials science beyond the current state-of-the-art. Urgent and timely problems in Sweden are addressed but at the same time the program will drive solutions to filtering problems on a global scale.

The set of developed filters will be extensively tested within the Mistra TerraClean program under both laboratory and field conditions using smart online sensors and offline analytical techniques. Their performance in removing chemical constituents from air and water will be evaluated and their expected longevity in industrial applications will be estimated. However, materials alone do not make a product. The Mistra TerraClean program will furthermore aim to integrate the smart materials in a platform for cleantech air and water solutions based on smart, safe and sustainable technologies, which in turn will be a crucial step towards increased resource-efficiency and a circular economy.

By a close setting between academia, research institutes and industry, Sweden will increase its competitive advantage through access to and IP ownership of advanced technology. In a unique and interdisciplinary collaboration between Swedish world-class scientific groups and industrial partners, we will systematically develop functionalities of smart materials and create an arena for smart materials solutions, thus translating the expertise into economic value – jobs, exports and competitiveness. The Mistra TerraClean program will contribute not only to the technological field but also to the development of integrated, circular system solutions, the support of new business models for co-utilization and re-use, as well as to innovative design.

Program start: April 2017

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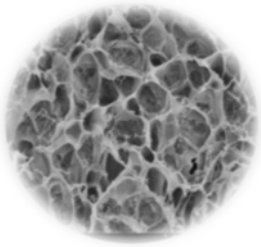


PROGRAM GOALS

The Mistra TerraClean program goal is to develop and bring to market a series of nano- and mesoporous smart filters, in which each filter is tailor-made to adsorb a predefined group of chemicals in industrial applications or from the surrounding air or water. The goal is to develop intelligent, resource- and cost-efficient materials for improved and integrated solutions for managing air quality, water quality and chemicals in industrial and municipal operations. It concerns removal of heavy metals, SOx, NOx and other inorganic substances as well as organic substances (persistent organic pollutants, drug metabolites, CO2, nitrogen oxides and other noxious gases), and fouling microorganisms. By smart materials in this context we mean engineered structures with integrated systems able to respond in a controlled way to external stimuli to achieve the following effects:

Characterize the condition of a filter with respect to integrity, state of health, biofilm, and/or degree of saturation interactively in mode of operation and provide direct response.

Control the filter by stimuli-responsive properties. The materials respond to and perform in a controlled fashion based on operating stimuli by changing e.g. voltage, pH, illumination, pressure, salt, temperature, or ion strength.

These materials will be tested in pilot experiments aimed at demonstrating feasibility, effectivity, safety and economy. We will perform case studies together with intended user companies to address our core aims of managing air quality, water quality and chemicals.

PROGRAM WORK PACKAGES

Work Package 1 Materials development and structuring

Development of different tailored functionalized materials and integration of stimuli-responsive functions using naturally occurring and commercially important raw materials indigenous to Sweden. Key questions involve development of materials with functionally-enhanced natural and engineered porous materials, synthesis, refining, functionalization, characterization and structuring. A vital question is how to integrate stimuli-responsive functions through targeted chemical functionalization and/or structuring. The responsive functions will relate to various field or adaptive chemistry induced changes.

Work package leader: Niklas Hedin, Professor, Stockholm University
Deputy leader: Maria Strömme, Professor, Uppsala University

Work Package 2: Smart filter design and validation

Design and manufacturing of filters and membranes based on smart materials and the development of methods to benchmark and validate their performance. A key question is to combine connectivity with mechanical and fluidic properties in a filter design that allows scaling of manufacturing to large volume filters. For photocatalytic purification devices, providing illumination inside 3D structures it will also be important to optimize fluid flow in 2D structure and find scalable designs and materials for photocatalytic fuel cells.

Work package leader: Mats Sandberg, Dr., RISE Acreo
Deputy leader: Aji Mathew, Professor, Stockholm University

Work Package 3: Application platform

Testing and evaluation of the novel filter materials and online sensors developed in work packages 1 and 2 under realistic conditions in collaboration with industry partners. Four specific case studies within water purification/air purification to drive the research and development in an iterative workflow. Key for driving innovation and implementation is to have an efficient communication between the needs and competence provided by the problem owners (industry representatives), and the possibilities provided by the solution providers (research organizations and suppliers).

Case study A: Case study A – Removal of heavy metals, concentration of acids in flue gas acid stage and condensate stage from waste incineration

Case study B: Removal of dioxin and other harmful volatile organic compounds (VOCs) in flue gas from waste incineration.

Case study C: Removal of metals and nitrogen/phosphorous containing compounds in process water from mining and the pulp and paper industry and waste water treatment plants.

Case study D: Removal of pathogens, heavy metal, and dissolved organic matter (DOM) in drinking water.

Work package leader: Jan-Erik Nordström, Docent, IVL
Deputy leader: Pia Wågberg, RISE Bioeconomy

Work Package 4: Human and Environmental Safety, Life Cycle Assessment, Science and Society

Life cycle assessment of potential environmental impacts of the developed smart materials and a risk assessment of hazards to humans and the ambient environment. Life cycle assessments and life-cycle cost analyses of potential environmental impacts and a risk assessment of hazards to humans and the ambient environment will be performed and documented for relevant regulatory body interaction and approval. The work will also support the design and interpretation of results from a variety of case studies.

Work package leader: Ian Cotgreave, Professor, Swetox and Karolinska Institute
Deputy leader: Åsalie Hartmanis, M.Sc., SwedNanoTech

Work package 5: Management, IP handling, and communication

Implementation of routines for communication, document exchange, technical and economic progress reporting, to assure that resources allocated for R&D objectives are properly utilized.

Program director: Ulrica Edlund, Professor, KTH
Communication manager: Åsalie Hartmanis, M.Sc., SwedNanoTech

PARTNERS

In alphabetical order

Akzo Nobel Coatings International B.V.
Akzo Nobel Chemicals International B.V.

Biokol AB

Boliden Mineral AB

Borregaard ASA

Disruptive Materials AB

IVL Svenska Miljöinstitutet AB

Karolinska Institutet - Swetox

Kungliga Tekniska Högskolan
Division of Fiber Technology
Division of Functional Materials
Division of Polymer Technology

MoRe Research Örnsköldsvik AB

NeoZeo AB

RISE Bioekonomi INNVENTIA AB
RISE Research Institutes of Sweden AB
RISE Acreo AB

Stockholm International Water Institute, SIWI

Stockholms University
Department of Materials and Environmental Chemistry

Svenska Aerogel AB

Svenskt Vatten AB

SwedNanoTech AB

Uppsala University
Nano Technology and Functional Materials

Vattenfall AB

APRIL – SEPTEMBER 2017:

PREPARING TO LAUNCH

With a formal start on April 1, 2017, and during the first months of the program, the activities of the program consortium included:

A **consortium agreement** stating the framework for cooperation within Mistra TerraClean was drafted and finalized in September 2017. The agreement maps out the general regulations for results and IPR generated in close cooperation between partners from university and other partners, as well as governance, publication strategy, confidentiality, and terms of termination.

A **program plan in detail** mapping out the activities of the entire program was drafted and finalized in September 2017.

A **program budget** was drafted and finalized in September 2017.

Steering documents to serve as guides which explain the work process, the organization and the publication strategy within the program.

A **platform for internal communication** and document archiving with accessibility to all partners was established and put to use. The project management system Basecamp is used.

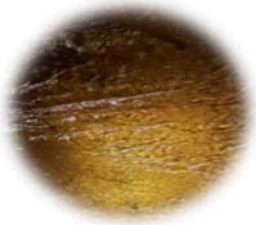
A **code of conduct** was drafted and implemented**,** summarizing the principles, values, and responsibilities of each partner that will be the proper practices for Mistra TerraClean. Every participant undertakes to respect the code of conduct throughout the program.

A **publication process** was established which applies to those working in Mistra TerraClean and who intends to publish items for public access, in scientific journals, popular science journals, conference abstracts or proceedings, posters or articles of debate.

A **steering group** was established. The steering group consists of 1) the program director, 2) the communication leader, and 3) the leader for each work package. Additionally, Mistra or the coordinator may appoint additional group members with rights to be present and speak at steering group meetings.

Board and advisory board representatives were identified and invitation processes initiated.

Financial routines were established to maintain firm control of program finances and resources on a regular reporting period basis.



OCTOBER 2, 2017:

KICK-OFF

The Mistra TerraClean consortium visited Käppalaverket at Lidingö to learn firsthand about the immediate and future challenges in water purification.

The Käppala Association treats wastewater from over 500 000 inhabitants in eleven municipalities located north and east of Stockholm. The treatment plant, the Käppala wastewater treatment plant, is Sweden's third-largest, and employs a very effective treatment process. Our hosts, development engineers Stefan Erikstam and Catharina Grundestam gave us a guided tour of the underground facility where wastewater is treated in large chambers blasted into the rock. Every year, Käppala treats approximately 50 million cubic meters of wastewater.

Many issues within municipal waste water treatment was discussed providing inspiration to coming efforts within Mistra TerraClean to invent and develop smart materials for this and related purposes. In addition to wastewater purification, Käppala activities on biogas and sludge production are of high relevance to Mistra TerraClean. Upcoming changes in regulation on the European Union level will have a clear impact on the discharge requirements and spurs a continuous development of technology to make the treatment process even more efficient.

Following the visit to Käppalaverken, the first consortium meeting – a general assembly – was held at Villa Brevik, Lidingö, drafting the roadmap for the coming activities of the program.

Käppala underground wastewater treatment plant

Stefan Erikstam

OCTOBER - DECEMBER, 2017: RESEARCH AND DEVLOPMENT

Within work package 1, the production of base and modified materials is up and running. Uppsala university, in collaboration with Disruptive Materials AB, produced porous magnesium carbonates and screened for adsorption characteristics. Gas separation and phosphate absorption studies will follow. Activated carbons, a key base material in the program, was produced at Stockholm university. Stockholm university in collaboration with KTH Polymer technology initiated chemical modification processes for the functionalization of nanocellulose with responsive groups. Stockholm university, KTH Polymer technology, and Vattenfall jointly initiated a survey to identify suitable functional groups which, immobilized on cellulose and cellulose-hemicellulose hybrid materials, will effectively capture target heavy metal contaminants in flue gas condensates. KTH Functional materials investigated capacitive deionization for removing and recuperating metal ions from dilute industrial waste waters. KTH Fiber Technology developed freeze-linked cellulose structures and started a collaboration with RISE Acreo in work package 2 to make these structures useful as interactive material modules and to identify suitable modifications to the material.

Within work package 2, the development, as well as strategies for integration into base material structures, of optical fiber sensors and filters and membranes with “simple“ sensors was initiated Printing simple structures, inter-digit electrodes for impedance measurements or sensors for streaming potential on membranes serve to learn the ropes on connecting and building smart filters. Work package 2 initiated the compilation of a list of standards and protocols relevant for the characterization of filter and filter material performance. The aim is to provide a common platform for characterization, allow for benchmarking against reference materials, and to enable comparisons between studies.

Work package 3 started screening with pure, non-modified materials for the first iteration and also in the small scale with the aim to bridge the gap between work packages 1 and 3. What is needed from a materials perspective to work in the future case studies? IVL attended the SwedMining meeting.

Start-up actions within work package 4 involved interaction with each emerging material and case study, to provide a top-down, high-level appraisal of the “risk-benefit” profile of new materials and application to case studies from a human and environmental safety perspective. This included identification of any stop-go criteria we think relevant for an emerging material. Work package 4 partners also started the work to define the modes of interaction for each of the stakeholder groups and to devise a flexible “conveyer-belt” of communication of project milestones and landmarks as they occur.

Camfil AB contacted Mistra TerraClean with an interest to join the program. Camfil AB is a multinational company and world leading in providing commercial and industrial systems for air filtration and air pollution control.

Results so far:

3 Ph.D. students was requited to work full time within Mistra TerraClean. Starting dates: January – May 2018.

Base material production started.

Exilva nanocellulose is a key base material within Mistra TerraClean. Exilva samples were delivered from Borregaard to a number of partners active in work packages 1, 2 and 3.

Quartzene, was delivered by Swedish Aerogel to work package 3 for initial screening of potential capacity of heavy metal ion removal from wastewaters.

A mathematical model development to predict the output of the capacitive deionization unit developed at Functional Materials, KTH in Kista.

Letter-of-intent from Camfil AB to join Mistra TerraClean as a full partner and contribute with 500 kSEK.

Brainstorming and planning at a work package partner meeting

OCTOBER - DECEMBER, 2017:

COMMUNICATION AND OUTREACH

Dissemination of the scientific results will be done in leading international journals, and through presentations at international conferences. There will also be publications in Swedish media, and participation in outreach activities such as seminars, conferences, and workshops, directed to practitioners (government, industry, media) and the public. A web page for the program was set up. Other social media channels will also be used and a newsletter specifically aimed at the platform was created. We also designed the graphic profile of Mistra TerraClean, including a folder, a web page, letter and presentation templates, and logotypes.

Results so far:

Smarta Material renar luft, **Ny Teknik**, 2017, 38, 9. September 21, 2017.

Mistra TerraClean established as a member of WaterCentre@KTH

SwedNanoTech contacted the communication managers from the other ongoing Mistra programmes and arranged a joint communication strategy meeting.

Web page www.mistraterraclean.com

Presentation folder

Logotype

MISTRA TERRACLEAN

FINANCIAL REPORT, 2017

RECEIVED AND SPENT FUNDING SEK	RESULT 2017	BUDGET 2017	DIFFERENCE
BALANCE, start 2017	0	0	0
IN			
Mistra funding	7 665 200	10 963 000	-3 297 800
Partner contributions	500 000	500 000	0
Other			
SUM	**7 807 000**	**11 463 000**	**-3 297 800**
COSTS			
Salaries	1 902 971	7 258 000	-5 355 029
Travel	41 225	144 000	-102 775
Consumables	71 008	763 000	-691 992
Other direct costs	127 762	400 000	-272 238
DIRECT COSTS	**2 142 966**	**8 565 000**	**-6 422 034**
Indirect costs incl. premises	591 570	2 398 000	-1 806 431
SUM	**2 734 536**	**10 963 000**	**-8 228 464**
RESULT	**5 072 464**	**500 000**	**4 930 664**

Stockholm, March 2018.