C1 Value

Academy Programme 2020–2023

Programme memorandum

ACADEMY OF FINLAND

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1. Background

Finland is one of the signatories of the Paris climate agreement and committed to becoming carbon-neutral by 2045. The target can be achieved not just by cutting carbon emissions but also by promoting solutions that reduce the volume of carbon compounds in the atmosphere. In addition to carbon capture and storage, we also need new sustainable means and methods to utilise carbon compounds and turn them into chemical materials and products.

Atmospheric carbon compounds can be captured, stored (CCS, carbon capture and storage) and utilised (CCU, carbon capture and utilisation) in the production of various chemical products and materials. C1 compounds (CO2, CO, CH4, CH3OH) are potential sources of raw material for the production of, for example, plastics, lubricants, platform and fine chemicals as well as fuels. The industrial sector, too, urgently needs to lower greenhouse gas emissions and increase resource and process efficiency. Slowing down climate change is one of the biggest global challenges facing humankind and the scientific community in this century.

The utilisation of C1 compounds and especially carbon dioxide as starting materials is a popular research topic worldwide. Several new, mostly catalytic, synthesis methods are under development in order to convert C1 compounds into chemical products and new materials.

There is still a lot to learn about molecular phenomena, and there are still major challenges to be solved when it comes to the development of methods and processes, which are often related to the activation of these fairly unreactive starting materials. Carbon dioxide and methane are naturally persistent compounds.

Another exciting area of research worldwide at the moment is CCU, carbon capture and utilisation, which involves capturing carbon dioxide from the air or flue gases and either utilising it as is or converting it into raw material for the production of hydrocarbons, for example. From the perspective of carbon capture, direct air capture (DAC) and the related new chemical material technologies can be seen as genuine future solutions for lowering atmospheric carbon dioxide concentrations globally.

Capturing carbon dioxide in connection with production, before it is released into the atmosphere, helps lower our carbon footprint. Increasing our carbon handprint, in turn, refers to enabling customers to reduce their carbon dioxide emissions by providing them with climate-friendly products and solutions. As climate change is a global problem and as the world is now definitely aware of the issue thanks to the IPCC's October 2018 report, there is global and rapidly growing demand for climate-friendly products, services and solutions. The C1 Value Academy Programme is aimed at increasing dialogue between businesses, the public and the research community and at boosting Finland's strategic expertise in the field. The programme promises to help businesses both

reduce their carbon footprint and increase their carbon handprint. The Finnish chemical industry published a joint mission statement called Carbon-neutral Chemistry 2045 in January of 2019. Chemical companies are in the process of developing and adopting solutions that will enable the industry to achieve net carbon neutrality by 2045.

C1 Value ties in with Business Finland's Bio and Circular Finland and Smart Energy Finland programmes especially in respect of climate change, carbon neutrality, energy efficiency and circular economy.

2. Objectives

The C1 Value Academy Programme is aimed at making scientific breakthroughs, generating new know-how and boosting Finland's scientific competence. This will require interdisciplinary research cooperation that incorporates approaches from different fields as well as groundbreaking research. In addition to having scientific impact, the programme is hoped to significantly slow down the progress of climate change globally and to help Finland meet its climate targets.

In particular, the programme is designed to encourage researchers to adopt a more open-minded and interdisciplinary approach to all aspects of the field, combining, for example, chemistry, chemical engineering and process technology with materials science, systemic research, industrial ecology, biotechnology, circular economy and life-cycle thinking. Project teams are encouraged to explore the technological and financial feasibility of the solutions that they hope to develop already at the very beginning of the planning process.

C1 Value seeks to promote basic research in chemistry and chemical engineering in Finland. The programme also promotes both doctoral studies and postdoctoral careers in this field, which is vital for Finland's export trade. Cooperation between research teams and businesses makes it easier to identify needs, develop solutions and increase competitiveness, and the programme is also hoped to attract projects that are prepared to partner up with businesses.

The primary objective of the programme is to produce new scientific information and competence in the following fields:

- catalytic conversion and synthetic chemistry of C1 compounds, development of homogeneous and heterogeneous catalysts and catalytic reactions, (stereoselective) platform, fine chemical and polymer syntheses, and related molecular modelling
- mechanistic and kinetic study of C1 reactions, thermodynamics and reaction engineering
- electrochemical and photocatalytic reactions of C1 compounds
- direct air capture of carbon dioxide

- capture of carbon dioxide from process gases or flue gases in projects that are particularly ambitious in terms of scientific standard and innovativeness.

The programme also has the following social and operational objectives:

- encouraging the study and resolution of key issues in research in order to create potential for industrial exploitation
- steering research towards the objectives set out in the UN's 2030 Agenda for Sustainable Development
- facilitating the creation of new multidisciplinary research teams and national and international collaboration networks
- promoting the mobility of doctoral candidates and researchers
- improving the international competitiveness of research and industry through cooperation
- promoting open science and research.

3. Scope

3.1. Conversion of C1 compounds

Key themes in respect of the conversion of C1 compounds include the reactions of carbon dioxide in particular but also carbon monoxide and methane as well as other C1 starting materials that are compatible with the programme's objectives, such as methanol, hydrogen cyanide and synthesis gas, and turning them into more valuable products. C1 starting materials can be converted into, for example, new platform and fine chemicals, monomers and polymeric materials by means of catalysis and synthetic chemistry. The new carbon-dioxide-based chemical materials and polymers created by conversion, as well as material concepts based on these, have the potential of becoming an important carbon sink in the future.

Carbon dioxide can be converted into other hydrocarbons through electrochemical reactions, or it can be activated electrochemically to produce carbamates and cyclic carbonates, for example. Photocatalysis and photocatalytic reactions can also be used in the conversion of C1 starting materials.

Although a lot of international research has been conducted in the aforementioned fields in recent decades, several unanswered questions remain in respect of the underlying C1 activation mechanisms and molecular processes, which can be solved by basic research in synthetic chemistry, catalysis, molecular modelling and chemical engineering before major breakthroughs are possible in the development of future technologies. The practical application of polymer synthesis also requires the understanding of molecular phenomena and

correlations between polymer structures and characteristics that basic research can provide.

3.2. Capture of carbon dioxide

Carbon dioxide can be captured from flue gases produced by power plants that run on fossil fuels or biomass, which typically have a carbon dioxide content of 3–15 vol%. Industrial process gases can contain carbon dioxide in higher concentrations, but the potential of utilising it is lower. The primary capture techniques are post-combustion capture, pre-combustion capture and oxy-fuel combustion. More recent experimental techniques include those based on solid sorbents and membranes.

Approximately half of all carbon dioxide emissions are attributable to moving or small sources that are incompatible with the aforementioned capture techniques. One of the most notable scientific and technological challenges in the future will be to efficiently capture carbon dioxide directly from the air (DAC). The biggest obstacle to using the technique is the considerably lower atmospheric carbon dioxide concentrations, which amount to approximately 400 ppm. Scientists have successfully developed new and promising chemical sorbent materials in recent years that can be used to capture carbon dioxide directly from the air with the help of, for example, basic solutions or various hybrid materials, such as metal–organic frameworks (MOFs). Like with chemical C1 conversion, future breakthroughs are contingent on additional investments in basic and applied research in this field.

The C1 Value programme is hoped to attract applications relating to revolutionary, cost-effective technological solutions for carbon capture that create potential for its more widespread utilisation.

4. Implementation

The Academy Programme is aimed promoting scientific regeneration. It encourages multidisciplinary and interdisciplinary research. The programme was drawn up by the Academy of Finland's Research Council for Biosciences, Health and the Environment and the Research Council for Natural Sciences and Engineering.

4.1. Funding

C1 Value is an Academy Programme funded and coordinated by the Academy of Finland. The Academy Board has set the programme's funding budget at 6 million euros.

4.2. National cooperation

The programme ties in with Business Finland's Bio and Circular Finland and Smart Energy Finland programmes. Joint projects between businesses and research organisations can be funded through Business Finland's programmes on the basis of the Co-Innovation model depending on the competence of C1 Value project teams. Where possible, the programme will seek to collaborate with foundations.

4.3. International cooperation

C1 Value will aim to collaborate selectively and possibly launch joint calls with foreign research funding agencies that support high-level scientific research, insofar as this collaboration benefits Finnish research in the field. Depending on emerging needs and opportunities the programme will also seek the collaboration of similar foreign programmes, projects and leading research institutes in the field.

4.4. Schedule

Funding will be made available to projects and consortia scheduled to run for no more than four years. The funding period starts on 1 January 2020 and ends no later than on 31 December 2023. The timetable for the call and the review process is set out in more detail in Chapter 5 of this memorandum. The programme's kick-off seminar will be held in early 2020. Separate information will be provided on the funding sources, research areas, schedules and application processes of any future supplementary calls.

4.5. Programme steering group and coordination

The programme is run by a steering group composed of members of the Academy's research councils and other expert members. The programme strives to support and promote the development of the selected projects into a coherent and cohesive structure through active cooperation and exchange of information. Programme coordination rests with the programme managers and the project officer, whose role it is to facilitate achievement of the programme's objectives together with the steering group and the participating projects.

The PIs of the projects selected for funding under the programme will be required to

- assume responsibility for and report on the scientific progress of the project and on the use of the funds in accordance with the instructions of the programme manager and relevant funding bodies
- ensure that the whole research team attends all events organised by the programme coordinators, and facilitate exchange and cooperation between research teams in the programme

- take part in producing reviews, syntheses and information material around the programme, and actively disseminate information about the programme's progress and results on public and scientific forums.

During the course of the programme, the research projects will participate in events arranged together with end-users of research results and in any other activities designed to disseminate information to stakeholders.

4.6. Final evaluation

The Academy Programme will be evaluated on its completion to assess implementation and outcomes. The scope and aims of the evaluation will be defined during the course of the programme, but it may consider e.g. the

- attainment of the programme's aims
- implementation
- achievement of intended impacts
- national and international cooperation.

5. Application guidelines and review criteria

The C1 Value Academy Programme has a two-stage call. At the first stage, applicants submit letters of intent including short plans of intent (guidelines provided in connection with the Academy's April 2019 call). The non-negotiable deadline for letters of intent is 24 April 2019 at 16.15 local Finnish time. The steering group will make a proposal to the programme subcommittee appointed by the Academy Board on projects that would best match the programme objectives based on the letters of intent. Priority will (in the event of projects of equal scientific merit) be given to projects that demonstrate genuine and credible cooperation with the business sector that can be deemed to increase their societal impact. The projects selected to proceed to the second stage (to submit full applications) will be notified of the programme subcommittee's decision in June 2019.

Applicants requested to submit full applications must prepare a complete research plan and submit it in the Academy's online services by 4 September 2019 at 16.15 local Finnish time. The deadline is non-negotiable. The guidelines for full applications are provided in connection with the Academy's April 2019 call. The cost estimate must be realistic and justified by type of expenditure in the research plan.

On the basis of the scientific review of the applications and considering the programme's objectives, the steering group will prepare a proposal to the programme subcommittee on the projects to be funded. The subcommittee will

make the funding decisions in November 2019. Any supplementary calls will be scheduled separately.

The letters intent will be reviewed by a panel consisting of steering group members and possibly other experts. The full applications will be peer-reviewed by an international expert panel.

The review of applications will be carried out in line with the general review criteria for Academy Programmes (see Guides for reviewers on our website). Besides the general review criteria, focus will also be placed on the objectives specific to the programme, as described in Chapter 2 of this memorandum. This aspect will be considered on the review form under section “Relevance of the project to the Academy Programme”.

6. More information

This programme memorandum is available as a PDF download at www.aka.fi/c1value > EN.

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