Cover Page

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Table of Contents **Page**

Proposal

1: Scientific and/or technical quality, relevant to the topics addressed by the call

1.1 Concept and objectives

The fundamental objective of the project is the further integration of existing European research facilities to a grid of reaction chambers in a continuation of the EUROCHAMP project. These facilities were created to study the impact of atmospheric processes e.g. on regional photochemistry, global change, as well as cultural heritage and human health effects under as realistic conditions as possible.

Although initial advances in the application of large chambers occurred in the United States and Japan, Europe now leads the world in the use of large, highly instrumented chambers for atmospheric model development and evaluation. Smaller chambers that were designed for specific purposes and are operated by experts in their fields excellently supplement the larger chambers. The integration of all these environmental chamber facilities within the framework of the EUROCHAMP-2 project promotes the retention of Europe's international position of excellence in this area and is unique in its kind worldwide.

The mobilisation of a large number of stakeholders dealing with environmental chamber techniques provides an infrastructure to the research community at an European level that offers maximum support for a broad community of researchers from different disciplines. The EUROCHAMP-2 project will foster the structuring effect of atmospheric chemistry activities performed in European environmental chambers within EUROCHAMP, since it offers the full availability of corresponding facilities for the whole European scientific community.

With respect to the project objectives mentioned above, three network activities, two joint research activities and a transnational access activity are formulated and cross-linked in the EUROCHAMP-2 project.

The major objective of the networking activities within the EUROCHAMP-2 project is to foster the effective interdisciplinary collaboration between the community of atmospheric scientists and colleagues from other disciplines that are closely related to it, which was successfully initiated within the EUROCHAMP project. This will be achieved through the three networking activities of EUROCHAMP-2.

The major objective of the joint research activities within the EUROCHAMP-2 project is the optimisation and further development of the infrastructures' performance. In order to meet these goals, two corresponding research activities are defined in the EUROCHAMP-2 work programme, namely the development and refinement of analytical equipment and the development of chemical and physical modelling techniques.

The infrastructure developed within the EUROCHAMP project has already been used by a large variety of scientists not only from the EU but also worldwide. Through the new transnational access activity the infrastructure will be opened more widely to attract even more colleagues from different disciplines related to atmospheric chemistry to make use of the infrastructure.

1.2 Progress beyond the state-of-the-art and overall strategy.

Although initial advances in the application of large chambers occurred in the United States and Japan, Europe now leads the world in the use of large, highly instrumented chambers for atmospheric model development and evaluation. Such chambers are excellently supported by smaller chambers, which were designed for specific experimental purposes and are operated by experts in their fields. The integration of all these environmental chamber facilities within the framework of the preceding EUROCHAMP project has significantly strengthened Europe's international position of excellence in this area and is unique in its kind worldwide.

The structure of the EUROCHAMP project with several networking and joint research activities was very successful and led to an improved knowledge in atmospheric chemistry, the development of updated and/or new models for describing atmospheric chemical/physical processes and the development of novel analytical instrumentation for atmospheric gaseous species and particles and which are at the forefront of worldwide research in this field. The EUROCHAMP project initiated a new structuring effect of atmospheric chemistry activities performed in European environmental chambers, since it offered the full availability of corresponding facilities for the whole European scientific community. The integrated environmental chamber infrastructure within EUROCHAMP significantly contributed to the improvement of the overall structure of the European research area, since it is an attractive opportunity for scientists from different disciplines involved in other infrastructural networks to enhance their research possibilities by finding solutions to questions addressed to overlapping areas between environmental and other interests. In this way, synergies and improved access of researchers to environmental chambers were developed.

Although transnational access activities were not part of the original EUROCHAMP project, the mobilisation of a large number of stakeholders and users dealing with environmental chamber techniques provided an infrastructure to the research community not only at a European level but also worldwide that now offers a maximum support for a broad community of researchers from different disciplines. In this respect, the EUROCHAMP project, which will finish end of May 2009, is an excellent example of cross-disciplinary interactions sharing and disseminating knowledge and related technologies across fields and between academia and industry related to or interested in the infrastructure.

The EUROCHAMP infrastructure is well recognised by colleagues worldwide and has attracted considerable attention, in particular with respect to adding to or using the database for environmental chambers which was developed during EUROCHAMP.

In this respect EUROCHAMP-2 will continue the work performed within EUROCHAMP now by adding new partners to the consortium and a variety of transnational access activities, which are now part of the proposed project.

The EUROCHAMP-2 project will be composed of 7 work packages as listed in the following section in Table 1.3 a, i.e., WP1 is the management work package, work packages WP2 to WP4 are associated with the network activities N1 to N3, respectively, work packages WP5 and WP6 are associated with the joint research activities JRA1 and JRA2, respectively, and work package WP7 is the new transnational access activity. This constellation proved very work effective within EUROCHAMP and the activities within the work packages will be continued, improved and augmented within EUROCHAMP-2. Due to the amount and complexity of the work to be performed in JRA1 and JRA2 the work packages WP5 and WP6 have been split into sub work packages WP5.1, 5.2, 5.3, 5.4, 5.5 and WP6.1, 6.2, respectively. This numbering terminology has been adopted since it reflects that the work in the sub packages is connected and falls within the general scope of the work to be performed within the JRA with which it is associated.

1.2.1 Management and Networking Activities

As in the original EUROCHAMP project the coordinator will serve as the control station of all activities within EUROCHAMP-2 (WP1). He takes care of all communication between the project participants. An International Assessment Group (IAG) and a Scientific Steering Committee (SSC) will be organised. Both boards will consist of a number of experts in the fields of research performed within the infrastructure of chamber facilities, policy and industrial affairs related to the infrastructures' topics. Questions or problems of interest from the European community will be addressed either to the IAG or the SSC depending on their subjects. Answers or solutions will be formulated there. This process was very efficient and successful within the EUROCHAMP project.

The successful networking activities initiated in EUROCHAMP such as i) the establishment of standardised rules as a method of quality assurance of the raw data analysis of the experiments in each facility, ii) intercomparison studies applying analytical devices in reference experiments under similar/identical conditions and ii) the intercomparison of instruments will be continued and improved within EUROCHAMP-2 (N1). The activities will be diversified quite extensively to include inter-comparisons of i) aerosol generation at the different chambers and ii) the turbulence and inhomogenetities occurring in different aerosol chambers. Efforts will also be made to establish connections with metrology activities.

The standardised data protocol for chamber studies which was defined in EUROCHAMP in order to make the results of experiments performed in the partners' facilities transparent and accessible to the scientific community has attracted a great deal of interest from the international scientific commumity. This WWW-based database currently contains 350 records and is accessible to the whole scientific community: it has proved a very effective method for the dissemination of the results. The database will be maintained, expanded and improved within EUROCHAMP-2 (N2). Work will be directed toward increasing the robustness, sustainibility and usability of the database. New tools are to be developed to make it more interactive and it is planned to open the database to data introduction by groups outside the consortium. The chamber experimental database is also to be suplemented by reference databases of IR and UV-Vis spectra and absorption coefficients.

For an optimum of integration of all the partners' facilities to a powerful grid of research instruments, periodical project meetings of all partners will be organised during the projects' duration. Here, the success of all research activities will be discussed together with selected associated users that will also be invited, depending on the corresponding agenda of each meeting. Furthermore, it is planned to organise several larger international conferences / workshops on infrastructure-related topics, e.g. the interaction of tropospheric chemistry with cultural heritage or human health. In order to reach a maximum of success, internationally established experts on the corresponding topics will be invited to join these conferences. The results will be published in suitable proceedings for dissemination to the scientific community. The above activities form the essential elements of the networking activities in N3.

1.2.2 Transnational Access Activities

Within the proposed EUROCHAMP-2 project the consortium will now offer transnational access to 12 installations. This activity will promote scientific excellence through the mobility of experts and access of research scientists, in particular new users, to the high quality EUROCHAMP-2 infrastructure. Such users may be engineers or scientists who need support from the infrastructure to conduct research in various fields of atmospheric environmental chemistry. Access to the installations will be offered free of charge and will be granted on the basis of proposals, which will be reviewed by the dedicated selection panel.

The call for the EUROCHAMP-2 transnational access activities will be a continuous call and proposals will be accepted at any time from any researcher or research team. Advertising the TNA activity will be done through the EUROCHAMP-2 website and by contacting colleagues in the research community.

Incoming proposals will be verified by the EUROCHAMP-2 office for formal compliance with the EU regulations and will be examined by the corresponding access provider of the infrastructure for the scientific quality of the proposal and the feasibility for the use of the facility. The EUROCHAMP-2 office will then forward the proposal to the selection panel, which will consist of members from the EUROCHAMP International Advisory Committee (IAC). The panel will judge the scientific content of the project and rank the proposals according to defined selection criteria. The final decision will be conveyed to the EUROCHAMP-2 office whose responsibility it will be to notify the applicant of the decision of the panel.

The selection panel will review the proposals with respect to the following criteria:

- Originality and scientific value of the proposal
- Interest to the scientific community
- New user
- Training benefit (young researchers)/mobility of expert

Through the process described above it is guaranteed that a) high quality services will be provided, and that b) high quality research will be conducted.

1.2.3 Joint Research Activities

The development of novel and the refinement of existing analytical devices of environmental chambers (JRA1: WP5.1, WP5.2 and WP5.3) in order to successfully detect atmospheric trace species such as VOCs, inorganic trace gases and radicals or to characterise aerosol particles is an essential task to be followed over the whole lifetime of such research facilities. The increasing demands for more comprehensive analytical techniques caused by the more and more complex scientific questions to be answered, requires a continuous improvement of the technical possibilities of a chamber. Accordingly, the present proposal includes a number of research activities focused on this topic. Besides the optimisation of existing devices, a number of analytical devices will be completely redesigned or used for the first time in conjunction with an environmental chamber. It is planned to develop highly specific equipment in a mobile form, so that such instruments may be transported to a chamber of choice and used in selected experiments independent of location. This philosophy will strengthen the idea of a real grid of environmental chambers forming a powerful infrastructure. In addition, the instruments to be developed (WP5.1 and WP5.2) will be of great use for future field campaigns for which sophisticated, improved analytical instrumentation is urgently required.

An important role in the development of analytical devices will be played by selected associated users, which can contribute to the infrastructure by their experience with highly specific analytical techniques. The partners together with the users will provide a broad platform of instruments, which will provide a perfect basis for performing intercomparison experiments in the different chambers. The definition of selected standard experiments to be performed in different chambers will serve as a measure of indirect quality assurance for chamber studies and related model applications.

One of the key processes controlling the influence of aerosol particles on the climate system is their ability to take up water. Knowledge with respect to the physical and chemical processes controlling the water uptake of atmospheric aerosol particles and also the modelling of these processes is still very rudimentary. Therefore, laboratory studies in chambers and other suitable devices, which investigate the transformation of aerosol particles and the resulting changes in, e.g., hygroscopic growth, activation, freezing behaviour, and optical properties etc., are highly beneficial. Despite the efforts made in the past, current chambers still lack some key features and possibilities that are urgently needed for further scientific progress. Therefore, in WP5.3 the thrust will be the provision of techniques for generating aerosol particles with well-defined physical properties for performing particle ageing, transformation and freezing experiments, and techniques for the characterization of aerosol particles in such experiments concerning their physical and chemical properties of interest.

At present, the global formation of SOA is poorly constrained, with estimates from modelling studies ranging from 12-70 Tg/year. Such estimates rely critically on laboratory measurements of the amount of SOA produced by individual SOA precursors, typically carried out in environmental ("smog") chambers. From these yield measurements, coupled with atmospheric models, it is currently believed that about 90% of SOA is due to biogenic hydrocarbons (terpenes and sesquiterpenes), which form SOA primarily by reaction with the hydroxyl radical (OH) and ozone (O_3). Recent field studies offer evidence that SOA is significantly more abundant than state-of-the-art SOA models predict in various regions of the troposphere. A roughly *tenfold* higher SOA production, 140 -910 Tg/year, has been inferred from global VOC mass budgets. In contrast to field observations, simulation chambers can provide SOA with well-defined origin under well-defined experimental conditions. So they are the appropriate tool to resolve this discrepancy by improving the chemical mechanisms and investigating the components and intermediates responsible for SOA formation and the composition and chemical and physical properties of SOA. Consequently, the project includes a number of new approaches to address these shortcomings in aerosol yields. The consortium aims, within work package WP5.4, to provide improved experimental approaches in the design of experiments that will allow experiments to be performed in smog chambers under more representative atmospheric conditions and provide data that will help to close the gap between experimental and model results in field experiments.

Historically, simulation chambers (smog chambers) have been primarily designed to link environmental conditions with photo-oxidants production (especially ozone formation) and other ozone-initiated processes. Today, the study of the interferences of urban surfaces on the oxidizing capacity of the atmosphere constitutes a very original approach. The use of simulation chamber experiments to assess the chemical impact of massive solid surfaces on air quality is fairly new. Smog chamber experiments are among the best tools to investigate these systems under realistic conditions. Nevertheless, these tools are not "perfect". Indeed, they comprise walls on which chemical transformations can also occur. Hence, it is of primary importance to work on the definition of suitable experiments to allow the chamber experiments to efficiently characterize this new atmospheric/indoor air chemistry. The choice of the materials, cleaning/passivating procedure, protocols, artefact identification etc. are all topics, which have to be documented, and the collective expertise available within EUROCHAMP-2 make the consortium ideally suited for this purpose. The work in WP5.5 is aimed at the development of methods for the study of surface reactions in chambers. The partners involved in this work package possess different types of facilities, which will allow them to investigate the surface reactions of a wide range of materials and assess their potential to affect ambient and indoor air quality.

The field of chemical modelling (JRA2) is directly coupled to each type of environmental chamber studies (JRA1). The analysis of chamber experiments without any model application is mostly not possible.

Accordingly, model activities are urgently necessary and a permanent companion of each experimental task. Models are widely used in atmospheric science, for example for prediction of climate change and in the development of mitigation strategies for air quality. These models rely on parameterisations, for example in the formation of aerosols, or on lumped chemical mechanisms. These models are extensively tested and compared, for example in the ACCENT intercomparison of global climate models. Less attention has been paid, though, to the need to base these parameterisations and mechanisms on sound, evolving laboratory data. Chambers are used to simulate chosen aspects of the atmosphere under carefully controlled conditions and so provide an ideal environment both for the provision of the detailed experimental data, and for the testing of the representations used in such models. The aim of JRA2 is to provide a modelling environment, which acts as a link between chamber experiments and atmospheric models, through the optimal design of experiments so that they provide a realistic representation of those atmospheric processes under investigation, and through the development and evaluation of parameterisations and mechanisms. The transfer of experimental results into models is non-trivial and improved trans-community approaches are needed and are targeted in JRA2.

The master chemical mechanism (MCM: http://mcm.leeds.ac.uk/MCM/) is the leading explicit chemical mechanism. It provides mechanisms for the oxidation of 135 of the main anthropogenic VOCs emitted to the atmosphere. It also includes a limited number of biogenic compounds. The MCM is based on laboratory measurements, including chamber data, but it also includes a large number of rate parameters that are estimated using comparisons with data on similar compounds, e.g. through structure activity relations. The MCM will be substantially revised and updated over the next few years and the methodologies developed within EUROCHAMP-2. WP6.1 will substantially inform that process, and facilitate the links between detailed chemical mechanisms, and the laboratory measurements on which they are based, and more concise representations that can be used in global and regional models.

In comparison with gaseous oxidative degradation mechanisms, model descriptions of the processes leading to the formation and transformation of aerosol particles in both chamber experiments and in the real atmosphere are poorly developed and in most cases the questions being asked of the models are ill-posed. There are several zeroth order questions, which must be addressed with respect to the organic component of atmospheric aerosols. Evaluation of models against appropriate experimental data from chamber experiments are essential to our understanding of this large, or even dominant, fraction of the ambient particle population and to the development of atmospheric models that can usefully capture the climatic and health impacts of aerosol. These questions can be summarised as follows and each link to work that is being performed within the work packages that comprise JRA2:

- *are all, or even the dominant, gaseous precursors of secondary organic aerosol considered in atmospheric models or in previous chamber experiments?*
- *are all, or even the dominant, processes leading to SOA formation and transformation represented in atmospheric models or adequately studied by means of chamber experiments? What can emerging modelling approaches do to inform the design of chamber experiments? What can emerging chamber experiment design do to inform appropriate model development?*
- *how do the components interact with primary material and with inorganic components including water during their formation?*
- *how do atmospheric aerosol particles interact with water vapour once they have been formed? Are the particles formed in chamber experiments chemically and physically representative of multicomponent atmospheric particles – do they interact with water vapour in the same way, are their physical properties the same? How can models inform the experimental design to improve their realism – concentration / seed aerosol / conditions / mixed precursors?*
- *what is the relative contribution of anthropogenic and biogenic precursors and how do they interact? Are the impacts of experimental deviation from atmospheric conditions the same for biogenic and anthropogenic SOA?*

Models for evaluation of chamber investigations of aerosol processes fall into two categories: those aiming to link independent simultaneous measurements of chemical and physical properties and those aiming to describe the evolution of aerosol physico-chemical properties with time. Some aspects of the former are significantly more advanced (e.g. hygroscopic models predicting water uptake or cloud activation from composition), though aspects of transformations in multicomponent systems are becoming more readily accessible to detailed model description. The measurement technique development work package WP6.2 will enable experiments, which can provide evaluation for models in both classes and hence provide an evaluated modelling infrastructure for chamber experiment interpretation.

1.3 S/T methodology and associated work plan

A list of the work packages within EUROCHAMP-2 is given in table 1.3a. The approach to be adopted within the project is similar to that being used in the current EUROCHAMP project and has been outlined together with the state-of-the-art in the preceding section.

The deliverables from the project are listed in table 1.3b1 according to the work package and activity (NA or JRA) with which they are associated. This is followed by a list of important milestones within the project that are tabulated in table 1.3c.

Detailed descriptions of each of the work packages for the management, the networking activities N1 to N3, the joint research activities JRA1 and JRA2 and the transnational access are given in tables 1.3 d1 to d7. Details of the time schedule for the tasks within the networking and joint research activities and associated work packages are shown in Table 1.3 e.