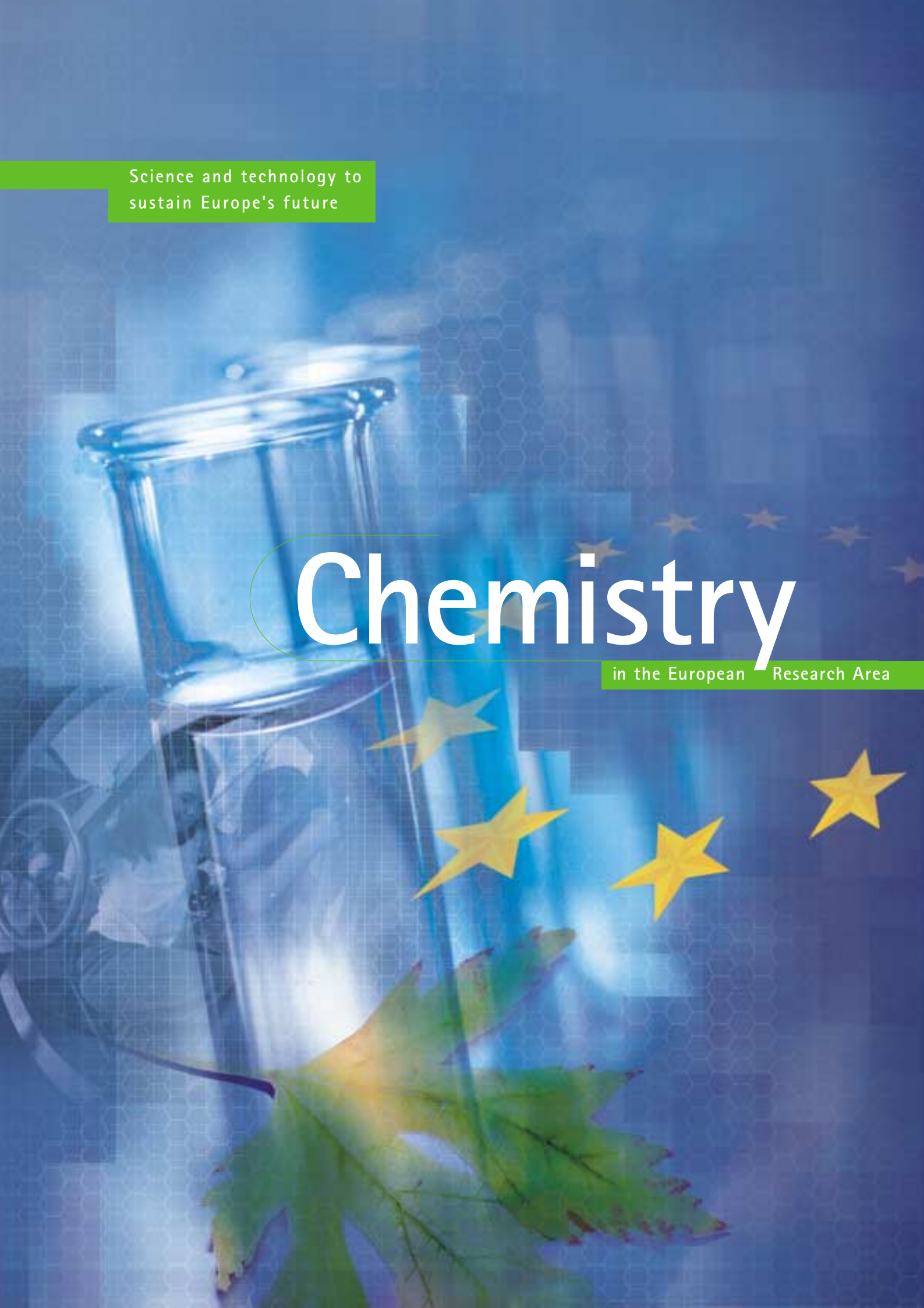
Science and technology to sustain Europe's future

Chemistry

in the European Research Area



Future chemistry

Chemical sciences and engineering underpin the excellent quality of life enjoyed by the citizens of Europe today. Many areas, such as new materials, biotechnology, agriculture and food, require an increasingly detailed understanding of the molecular world provided by the chemical sciences. Sustainable progress in health care, environmental protection and wealth creation is also dependent on advances in chemical sciences and engineering. AllChemE supports the creation of the European Research Area and has contributed to the formulation of the new European Research Framework Programme (FP6). This document presents AllChemE's recommendations and highlights some exciting developments in chemical sciences and technologies...

Chemical sciences will contribute to Europe's strategic goal of improved sustainable development by promoting the use and reuse of renewable resources, such as biomass, and improving process performance to reduce waste and emissions.

Over the next 20 years there could be a complete transformation of European chemical industry. The current typical chemical/industrial plants could disappear and be replaced by smaller less-obtrusive plants operating with maximised recycling of raw materials and process water. Such plants would produce no harmful effluent discharges into the environment, consume less energy and operate at lower temperatures and pressures.

Bio-mass will become the major raw material for base chemicals, energy carriers and pharmaceuticals. New processes to recover and recycle carbon dioxide will also feature. Technologies that will contribute significantly to new plants include efficient and durable membrane processes, supercritical extraction and bio-process technology. Precision chemistry, new product development and improved chemical analysis will stimulate and support innovative fields such as microelectronics, nanotechnology and intelligent materials.

The chemical sciences will contribute to an improved understanding of greenhouse gases with more detailed insights into their source, abatement measures, large scale transport phenomena and the global carbon cycle. The development of innovative materials with new uses will be one of the key issues in sustainable development. With the help of chemical sciences, materials will be stronger and lighter, will be easier to reuse or recycle and will be intelligent for specific uses in measurement and control processes. These innovations will require an integrated multidisciplinary approach to enable a coherent transformation of the chemical industry.

– making the difference

Catalysis is key to successful sustainable development and innovation in manufacturing. The impact of this branch of chemical science will be felt in areas as diverse as pharmaceuticals, energy, adhesives and optics.

New approaches in catalysis can achieve more efficient, higher yielding chemical synthesis, 'zero' or near-zero-waste processes and more energy-efficient processes capable of operating at lower temperatures. More research in chemical sciences is required to ensure that co-products can be recycled in an environmentally-friendly manner.

Catalysis will make increasingly important contributions to the quality of life in areas such as new and more effective pharmaceutical products, biotechnology applications, fine chemicals, including applications in personal care and food products, and new and improved materials such as textiles, building materials, coatings and adhesives.

Catalysis will also make major contributions to environmental protection via the destruction of environmentally harmful wastes, suppression of noxious vehicle emissions from bio-derived diesel and gasoline vehicles, introduction of cleaner fuels and lubricants for vehicles, development of new methods to generate and store hydrogen – a major future energy source, improved conversion of methane to valuable chemicals, and other energy related sustainable applications including photovoltaic and photo-chemically-based energy generation systems.

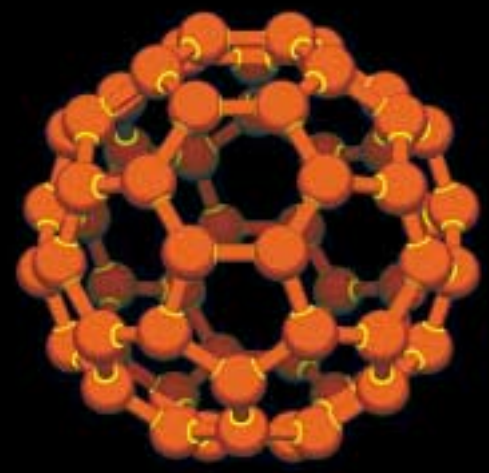
The ultimate goal of nanotechnology, the creation of nanoscale materials and devices, requires chemical science. Applications may include tiny machines capable of self-assembly and self-repair whilst performing precise molecular manipulations.

In electronics, chemical nanotechnology can control individual atoms and molecules to give ultimate quantum-scale semiconductors and integrated circuits, which together with superconducting nanowires will provide the basis for super-fast computers. Ultra-pure complex organic molecules will provide the key to developing biosensors and organic electronics to monitor health or control processes.

Nanoscale materials for batteries and related technology will boost battery life and improve energy storage. Environmentally-benign composite structures will be produced that are tailored at the molecular level to their application and afford longer service life and reduced energy consumption.

Nanostructured materials will have an increasingly important role in the remediation of wastes. This can take many forms, from using titanium dioxide nanoparticles to oxidise organic co-products and biological contaminants, including chemicals and viruses, to employing nanoscale scavengers to capture heavy metals in contaminated sites.

Nanotechnology processing of pharmaceuticals has already had enormous impact on drug delivery. By reducing drug particles to the nanoscale level, their bioavailability can be significantly enhanced. In this form they are small enough to pass through capillaries.



through innovation

In the life sciences chemistry is opening up new exciting opportunities arising from the ability to map the genome – the genetic information that characterises the properties and behaviour of individual organisms. Using genomic information the chemical sciences can deliver dramatic improvements in health care.

New exciting sciences are extending beyond genomics to proteomics, the study of the chemistry of the complex proteins that are the expression of the genome, and to metabolomics, the study of the interaction of these complex proteins with one another, other elements of physiology, biology and the external environment.

Chemical sciences are facilitating a greater understanding of individual living cells, in particular how they communicate with one another, protect themselves from harmful invaders and control their reproduction and death. Such improved understanding will lead to increased health benefits, improved medicines, optimised nutrition and greater longevity.

With increased knowledge of the molecular properties that underpin the mechanisms of living organisms, innovative chemical syntheses can be exploited to develop new molecular probes, drugs and antibiotics. Materials will be available that are biocompatible with the cytoplasmic and nucleic environments within the cell and consequently can act as the means of targeting drugs for optimised effect.

Chemical scientists will be able to selectively and specifically modify the functionality of living materials and assess the impact of such genetically modified (GM) materials. Future advances in the understanding of gene function and expression will broaden the range of GM-derived treatments and diagnostic capabilities.

Chemical sciences are vital to an improved understanding of food safety and health and nutritional issues. Epidemiologies of food-related diseases and genetic susceptibilities will be elucidated and the complex chemistry of production and manufacturing exploited to deliver healthier food.

Chemistry will underlie new, safer production and manufacturing methods for the delivery of healthier foodstuffs, including those based on biotechnologies and organic farming methods. The further development of chemoinformatics and modelling will afford robust traceability processes offering consumers increased confidence and choice in the food chain.

Food products derived from genetically-modified plants or micro organisms will provide the benefits demanded by consumers, for example a lowering of coronary heart disease through the physiological actions of dietary components. Alternative approaches to using genetic engineering in food products, such as developing transcription control in wild-type plant stocks, to choose which genes to switch on or off in a plant rather than direct genetic modification, will be developed.

The advance of metabolomics will deliver a better understanding of the nutritional value of food and explain how the bioavailability of food components during digestion relates to conditions such as obesity, allergenicity and transmission mechanisms for diseases such as BSE.

Brian Harris

Chemical sciences can contribute immensely to the future quality of life and international competitiveness. AllChemE is ready and willing to engage with society to improve perceptions and stimulate discussion for the benefit of all.

Surveys show that a majority of European citizens believe that science will conquer diseases such as cancer and AIDS and that scientists enjoy a high level of public trust. Chemical science can provide answers and the benefits of chemical science need to be demonstrated to all sections of society. Scientists are continually aiming to increase dialogue with governments, with opinion leaders and within their own communities.

AllChemE aims to support the development of education systems within the European Research Area that present chemical sciences and technologies as an essential part of modern culture and inspire more students of both genders to take up careers based on science and technology. Through the development of materials for schools and the promotion of a basic understanding of risk, the science curriculum at all levels will enable European citizens to participate with confidence in technological debate.

Scientific culture and its rich heritage is an integral part of the European Research Area. Science exhibitions, events and festivals are becoming increasingly innovative and popular.

Responsible science is central to many decisions taken by politicians and governments. AllChemE aims to ensure that scientific advice is open to scrutiny within a climate of transparency. Above all, scientists have a clear ethical responsibility that underlies all activities to improve the public perception of science and technology.

ALLIANCE FOR CHEMICAL SCIENCES AND TECHNOLOGIES IN EUROPE

AllChemE® – the chemistry alliance – www.allcheme.org

AllChemE is the representative body for chemistry and chemical engineering in Europe: AllChemE plays a unique and vital role in providing a focal point for promoting the strengths of chemical sciences and technologies. In bringing together five major European organisations, AllChemE is able to provide Europe with a highly effective and reliable single voice on matters of mutual importance to industry, academia and government. The organisations are:

CEFIC	European Chemical Industry Council
CERC3	Chairmen of the European Research Councils Chemistry Committees
COST	European Cooperation in the field of Scientific and Technical Research: Chemistry
FECS	Federation of European Chemical Societies
EFCE	European Federation of Chemical Engineering

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