



... BASF, was founded on April 6th, 1865 by Friedrich Engelhorn in Mannheim, Germany, and is thus 150 years old this year. To celebrate the firm's special anniversary, this Issue offers a collection of Reviews and Essays covering the contributions made by chemistry in the areas of energy, nutrition, and city life. Where will the energy that we need come from in the future? How can enough food and clean water for every single person be provided? What will the city of the future look like?

Appropriately the Cover Picture presents some highlights from the broad pallet of products produced by BASF: cathode materials for lithium-ion batteries (top), membranes for clean water (bottom), along with Xemium®, a new active ingredient and next-generation fungicide.

This Issue accompanies three BASF anniversary symposia in Ludwigshafen (9th/10th March), Chicago (23rd/24th June), and Shanghai (10th/11th November), at which authors in this Issue are lecturing. It is introduced by an Essay by A. Kreimeyer et al. on page 3178 ff. about the history of and the current direction of research at BASF, and followed by an Essay by G. M. Whitesides on page 3196 ff., in which he calls for a rethink in chemical research.

All twenty Essays and Reviews in this Issue demonstrate the huge importance of chemical research—it must, and will, contribute to raising the average quality of life of a growing world population.

Angewandte Chemie congratulates BASF on its anniversary.

How to contact us:

Editorial Office:

E-mail: angewandte@wiley-vch.de

Fax: (+49) 62 01-606-331

Telephone: (+49) 62 01-606-315

Reprints, E-Prints, Posters, Calendars:

Carmen Leitner

E-mail: chem-reprints@wiley-vch.de

Fax: (+49) 62 01-606-331

Telephone: (+49) 62 01-606-327

Copyright Permission:

Bettina Loycke

E-mail: rights-and-licences@wiley-vch.de

Fax: (+49) 62 01-606-332

Telephone: (+49) 62 01-606-280

Online Open:

Margitta Schmitt, Carmen Leitner

E-mail: angewandte@wiley-vch.de

Fax: (+49) 62 01-606-331

Telephone: (+49) 62 01-606-315

Subscriptions:

www.wileycustomerhelp.com

Fax: (+49) 62 01-606-184

Telephone: 0800 1800536 (Germany only)
+44(0) 1865476721 (all other countries)

Advertising:

Marion Schulz

E-mail: mschulz@wiley-vch.de

jspiess@wiley-vch.de

Fax: (+49) 62 01-606-550

Telephone: (+49) 62 01-606-565

Courier Services:

Boschstrasse 12, 69469 Weinheim

Regular Mail:

Postfach 101161, 69451 Weinheim

Angewandte Chemie International Edition is a journal of the Gesellschaft Deutscher Chemiker (GDCh), the largest chemistry-related scientific society in continental Europe. Information on the various activities and services of the GDCh, for example, cheaper subscription to *Angewandte Chemie International Edition*, as well as applications for membership can be found at www.gdch.de or can be requested from GDCh, Postfach 900440, D-60444 Frankfurt am Main, Germany.



GESELLSCHAFT
DEUTSCHER CHEMIKER

Get the **Angewandte App**
International Edition

Available on the
App Store

Enjoy Easy Browsing and a New Reading Experience on the iPad or iPhone

- Keep up to date with the latest articles in Early View.
- Download new weekly issues automatically when they are published.
- Read new or favorite articles anytime, anywhere.



Editorial



"I cordially invite you to bring in your creativity on our interactive anniversary platform", Andreas Kreimeyer, Research Executive Director of BASF, challenges all readers in the Editorial of this issue of Angewandte Chemie. This edition commemorates the 150th anniversary of BASF with a collection of Reviews and Essays that address the contributions of chemistry to the fields of energy, nutrition, and urban living.

A. Kreimeyer* _____ 3156–3158

150 Years of BASF

Service

Spotlight on Angewandte's Sister Journals

3168–3171

Author Profile



"My favorite composer is Richard Wagner. I really enjoy the orchestrations in his operas. If I could be any age I would be my current age. I always feel that we are doing our best work at the present time ..."
This and more about James A. Dumesic can be found on page 3172.

James A. Dumesic _____ 3172–3173

News



V. Wood



H.-J. Freund



C. Copéret



K. J. J. Mayrhofer



F. Hollmann

Science Award Electrochemistry:
V. Wood _____ 3174

Michel Boudart Award:
H.-J. Freund _____ 3174

Paul H. Emmett Award: C. Copéret 3174

DECHEMA Prize: K. J. J. Mayrhofer
and F. Hollmann _____ 3174

Essays

On April 6, 1865, Friedrich Engelhorn founded the company “Badische Anilin- & Sodafabrik” in Mannheim, Germany. This Essay, commemorating the 150th anniversary of BASF, introduces several outstanding examples of innovation from the history of BASF and highlights how chemical and technical competencies developed in the past still play an essential role in current projects.



BASF

A. Kreimeyer,* P. Eckes, C. Fischer,
H. Lauke, P. Schuhmacher – 3178–3195

“We Create Chemistry for a Sustainable Future”: Chemistry Creates Sustainable Solutions for a Growing World Population

Front Cover



CHANGE

Chemistry is in a period of change, from an era focused on molecules and reactions, to one in which manipulations of systems of molecules and reactions will be essential parts of controlling larger systems. This Essay traces paths from the past to possible futures.

Future of Chemistry

G. M. Whitesides* — 3196–3209

Reinventing Chemistry

Logos for Biodegradable Plastics



Japan: JBPA
GreenPla



Germany: DIN CERTCO
Komposterbar

Logos for Biomass Plastics



Japan: JBPA
BiomassPla



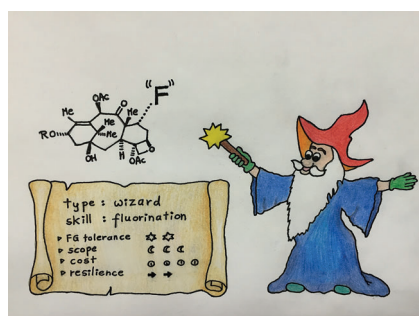
Japan: JORA
Biomass Mark

Currently used plastics are mostly produced from petrochemical products, but there is a growing demand for eco-friendly plastics. The use of bio-based plastics, which are produced from renewable resources, and biodegradable plastics, which are degraded in the environment, will lead to a more sustainable society and help us solve global environmental and waste management problems.

Sustainable Chemistry

T. Iwata* — 3210–3215

Biodegradable and Bio-Based Polymers:
Future Prospects of Eco-Friendly Plastics



Charming fluorine: This Essay examines the recent surge in late-stage fluorination reactions and outlines challenges that need to be overcome to increase the impact of modern fluorination methods on the synthesis of complex organofluorine compounds. It is outlined how an improved understanding of the bonding interactions of fluoride could lead to a new class of mild fluorinating reagents and a range of functional-group-tolerant reactions.

Fluorine

C. N. Neumann, T. Ritter* — 3216–3221

Late-Stage Fluorination: Fancy Novelty or Useful Tool?

For the USA and Canada:

ANGEWANDTE CHEMIE International Edition (ISSN 1433-7851) is published weekly by Wiley-VCH, PO Box 191161, 69451 Weinheim, Germany. US mailing agent: SPP, PO Box 437, Emigsville, PA 17318. Periodicals postage

paid at Emigsville, PA. US POSTMASTER: send address changes to *Angewandte Chemie*, John Wiley & Sons Inc., C/O The Sheridan Press, PO Box 465, Hanover, PA 17331. Annual subscription price for institutions: US\$ 11,738/10,206 (valid for print and electronic / print or

electronic delivery); for individuals who are personal members of a national chemical society prices are available on request. Postage and handling charges included. All prices are subject to local VAT/sales tax.

Industrial Chemistry

G. Prieto, F. Schüth* — 3222–3239

The Yin and Yang in the Development of Catalytic Processes: Catalysis Research and Reaction Engineering

A synergetic interplay: Catalysis is a key research field within BASF. Successful industrial chemistry is always the result of a combination of catalyst and process development. The interplay of catalyst chemistry and reaction engineering is discussed for processes such as the sulfuric acid production, ammonia synthesis, methanol synthesis, fluid catalytic cracking, and direct epoxidation of propylene.

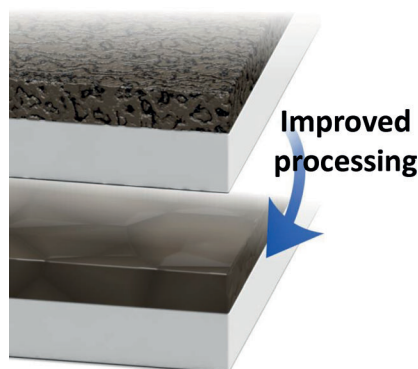


Minireviews

Photovoltaics

S. D. Stranks,* P. K. Nayak, W. Zhang, T. Stergiopoulos, H. J. Snaith* — 3240–3248

Formation of Thin Films of Organic–Inorganic Perovskites for High-Efficiency Solar Cells

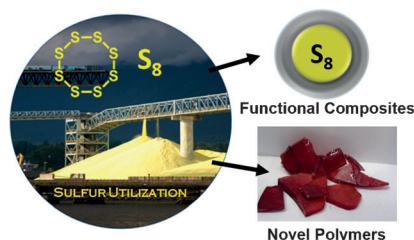


Quality of films: Most performance enhancements of organic–inorganic perovskite photovoltaics have been achieved through improved film quality. In this Minireview, various techniques for the formation of such films and the role of the solvent and precursors in the process are discussed, highlighting the material properties that are essential for high-efficiency solar cell operation.

Sulfur Chemistry

J. Lim, J. Pyun,* K. Char* — 3249–3258

Recent Approaches for the Direct Use of Elemental Sulfur in the Synthesis and Processing of Advanced Materials



Dealing with excess: The growing global production of excess elemental sulfur is an environmental concern and calls for novel approaches of utilizing the material as a feedstock for materials and industrial applications. This Minireview gives an overview of recent physical processing methods and synthetic procedures involving the direct use of elemental sulfur.

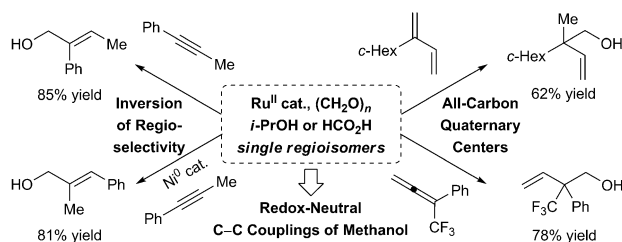
Heterogeneous Catalysis

D. Kim, K. K. Sakimoto, D. Hong, P. Yang* — 3259–3266

Artificial Photosynthesis for Sustainable Fuel and Chemical Production



Artificial photosynthesis is considered as the prime approach for the sustainable generation of energy. Significant progress has been achieved in recent years and this Minireview describes the current status and challenges in water splitting and electrochemical CO₂ reduction. Developments in the catalytic conversion of H₂ to complex products are outlined to present its role in the achievement of green chemistry.



Beyond hydroformylation: Ruthenium-catalyzed reductive couplings of paraformaldehyde with dienes, alkynes, and allenes provide access to products of hydrohydroxymethylation that cannot be

formed selectively under the conditions of hydroformylation. In certain cases, the regioselectivity of the C–C coupling can be inverted by using nickel catalysts.

Synthetic Methods

B. Sam, B. Breit,*

M. J. Krische* ————— 3267–3274

Paraformaldehyde and Methanol as C_1 Feedstocks in Metal-Catalyzed C–C Couplings of π -Unsaturated Reactants: Beyond Hydroformylation

Chemistry, pure and applied, is a science and an industry. By its power over the expressions of matter, it also displays the creativity of art. The field of chemistry is the universe of all possible entities and transformations of molecular matter, of which those actually realized in nature represent just one world among all the worlds that await to be created at the hand of the chemist.



Reviews

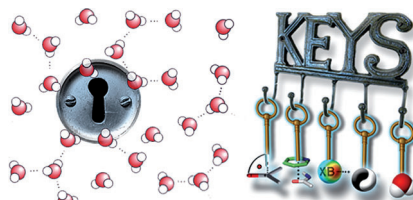
Supramolecular Chemistry

J.-M. Lehn* ————— 3276–3289

Perspectives in Chemistry—Aspects of Adaptive Chemistry and Materials



Both are required: Chemical model systems and the study of biological receptors are both required to understand molecular recognition processes. The identification and quantification of noncovalent interactions and deciphering the role of water are key elements for structure-based drug design. Several case studies are presented in which weak intermolecular interactions were applied to innovative ligand design and optimization.



Ligand Design

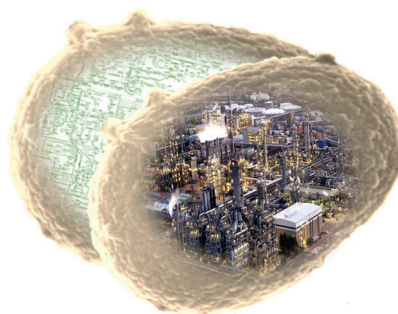
E. Persch, O. Dumele,

F. Diederich* ————— 3290–3327

Molecular Recognition in Chemical and Biological Systems



From cells to cell factories: Modern biotechnology combines systems metabolic and genetic engineering to enable microbes to produce natural value-added products. The picture illustrates the upgrade of the complex cellular metabolism into an industrial cell factory.



Biotechnology

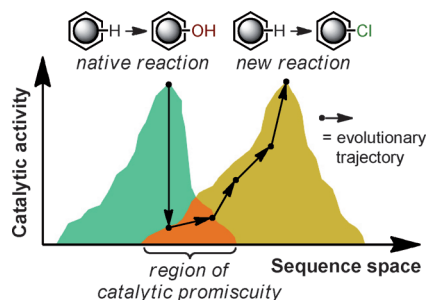
J. Becker, C. Wittmann* — 3328–3350

Advanced Biotechnology: Metabolically Engineered Cells for the Bio-Based Production of Chemicals and Fuels, Materials, and Health-Care Products

Biocatalysis

H. Renata, Z. J. Wang,
F. H. Arnold* — 3351 – 3367

Expanding the Enzyme Universe:
Accessing Non-Natural Reactions by
Mechanism-Guided Directed Evolution



Exploiting hidden talents: The engineering of enzymes to catalyze reactions not known in nature will expand the range of transformations that can be promoted by biocatalysis. This Review presents a common pathway by which new enzyme activities evolve in nature and examples of the use of a similar approach to create enzymes for non-natural reactions (see picture).

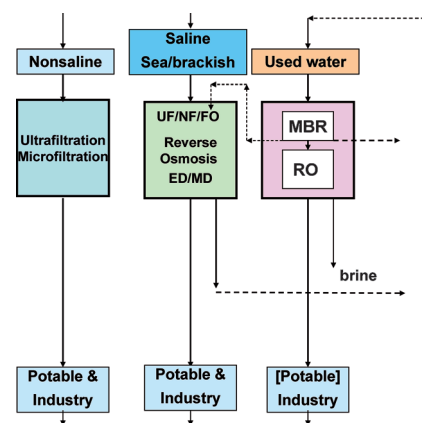
Water Purification

A. G. Fane,* R. Wang,
M. X. Hu — 3368 – 3386



Synthetic Membranes for Water
Purification: Status and Future

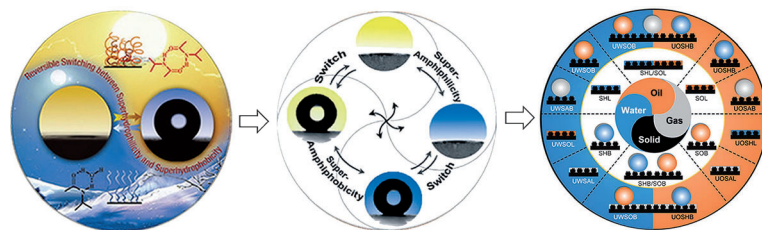
Membrane technology offers the best options to “drought proof” mankind on an increasingly thirsty planet by purifying seawater or used water. The driving forces for development of membranes for water production are described in this Review. An update is provided for developments in the various preparation techniques for the range of membrane types.



Super-Wettability

L. Wen, Y. Tian, L. Jiang* — 3387 – 3399

Bioinspired Super-Wettability from
Fundamental Research to Practical
Applications



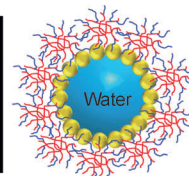
Wet, wet, wet: Surfaces with super-wettability, including three-dimensional, two-dimensional, and one-dimensional materials surfaces can be prepared. By combining different super-wettability proper-

ties, novel functional solid/liquid interfacial systems can be generated and integrated into devices for tackling many different problems.

Materials Science

A. R. Studart* — 3400 – 3416

Biologically Inspired Dynamic Material
Systems



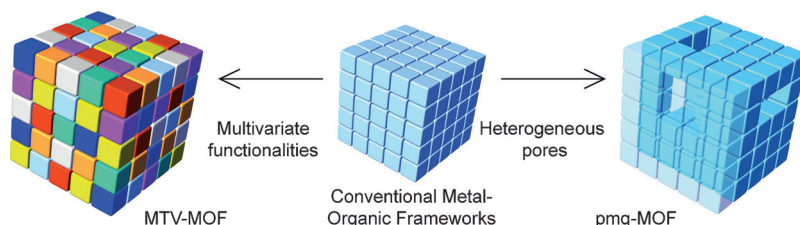
Hair-inspired sensors

Plant-inspired self-shaping objects

Cell-inspired interactive microcompartments

Dynamic material systems have been created to replicate the interactivity and adaptive response of hierarchical biological systems. Selected examples of bio-inspired hairlike sensors, shape-changing objects, and interactive microcompartment-

ments are reviewed to showcase the increasing level of complexity and the dynamic functionalities that can be achieved by using top-down fabrication technologies and bottom-up assembly approaches.



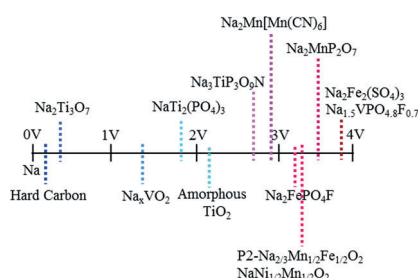
Mix and MOF: Most metal–organic frameworks (MOFs) are ordered and generally composed of only a few of repeating building unit. This Review describes how the use of various different

components in the MOF backbone and within the pores of the MOF can produce heterogeneity without losing the order (crystallinity) of the MOF structure.

Heterogeneous MOFs

H. Furukawa,* U. Müller,*
O. M. Yaghi* ————— 3417 – 3430

“Heterogeneity within Order” in Metal–Organic Frameworks

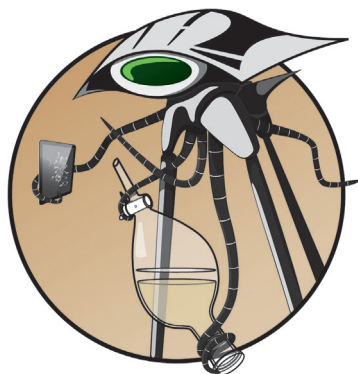


Below lithium: Concerns over the future cost and sustainability of resources of lithium has led to a global trend to develop low-cost sodium-ion batteries. Central to this has been the fast-developing field of non-aqueous batteries that could employ a plethora of materials for the positive and negative electrodes, and electrolytes. Apart from sustainability, they offer structural and electrochemical benefits compared to their Li analogues.

Sodium Ion Batteries

D. Kundu, E. Talaie, V. Duffort,
L. F. Nazar* ————— 3431 – 3448

The Emerging Chemistry of Sodium Ion Batteries for Electrochemical Energy Storage

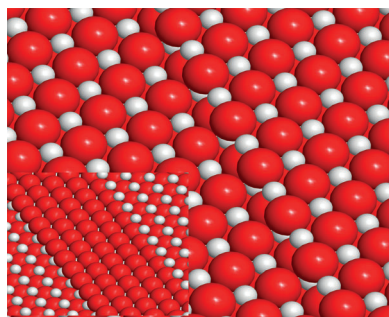


Transforming chemistry: New technologies and machines have found use as methods for changing the way we work, addressing the resource-based issues encountered in research laboratories by enabling chemists to adopt a more holistic systems approach in their work. This Review focuses on the concepts, procedures, and methods that have far-reaching implications in the chemistry world.

Machine-Assisted Chemistry

S. V. Ley,* D. E. Fitzpatrick, R. J. Ingham,
R. M. Myers ————— 3449 – 3464

Organic Synthesis: March of the Machines



Filling the gaps: The understanding of heterogeneous catalysis is built on a standard model of interface catalysis that was developed from surface physics and theory. This model has significant gaps with regards to transferring knowledge yielded to high-performance catalysts, and approaches to fill these gaps are proposed in this Review.

Heterogeneous Catalysis

R. Schlögl* ————— 3465 – 3520

Heterogeneous Catalysis



Supporting information is available on www.angewandte.org (see article for access details).



This article is accompanied by a cover picture (front or back cover, and inside or outside).



A video clip is available as Supporting Information on www.angewandte.org (see article for access details).



The Very Important Papers, marked VIP, have been rated unanimously as very important by the referees.



This article is available online free of charge (Open Access).

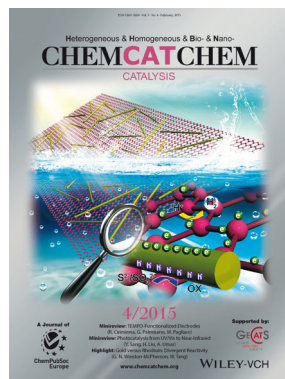


The Hot Papers are articles that the Editors have chosen on the basis of the referee reports to be of particular importance for an intensely studied area of research.

Check out these journals:



www.chemasianj.org



www.chemcatchem.org



www.chempluschem.org



www.chemviews.org