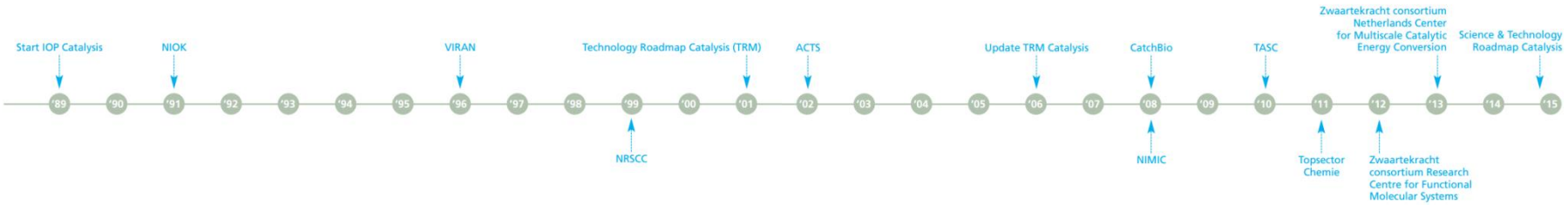
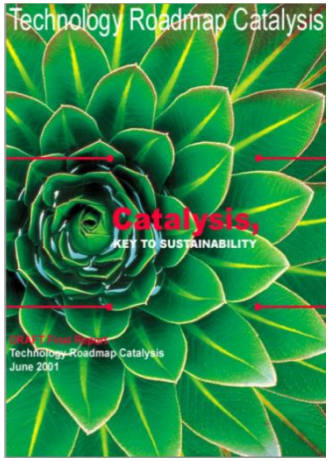
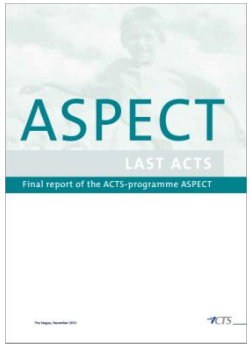
Roadmaps, an update

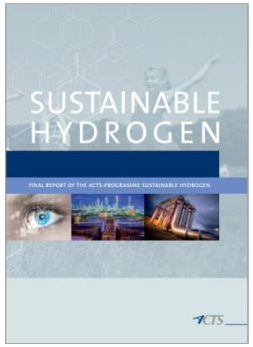
NCCC 2016

Historic background

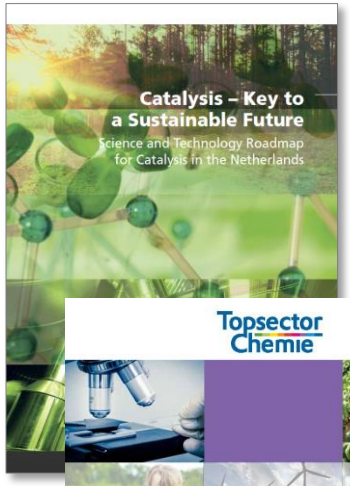




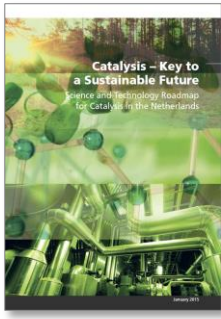


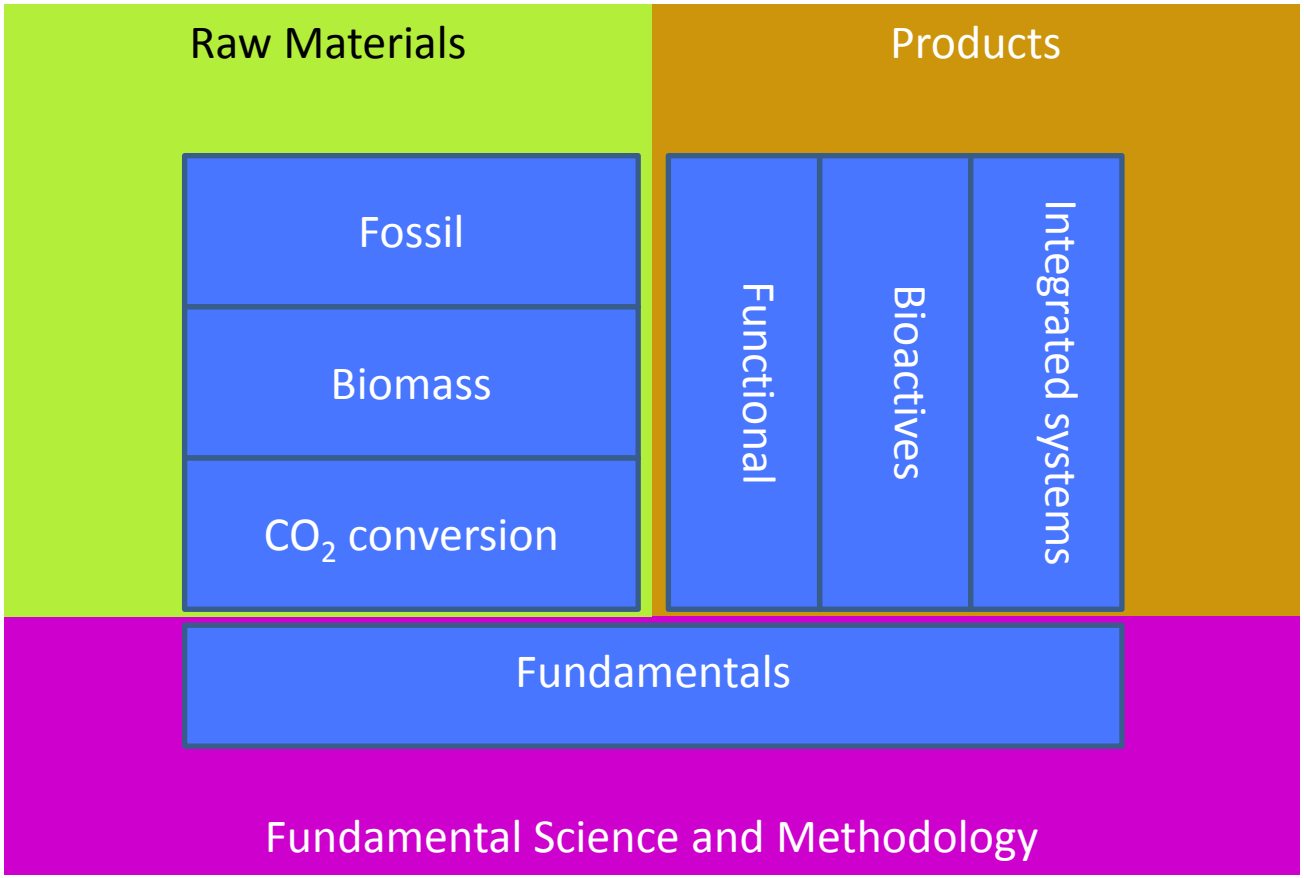


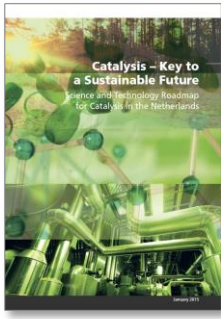
CatchBio



Structure of the 2015 Catalysis Roadmap

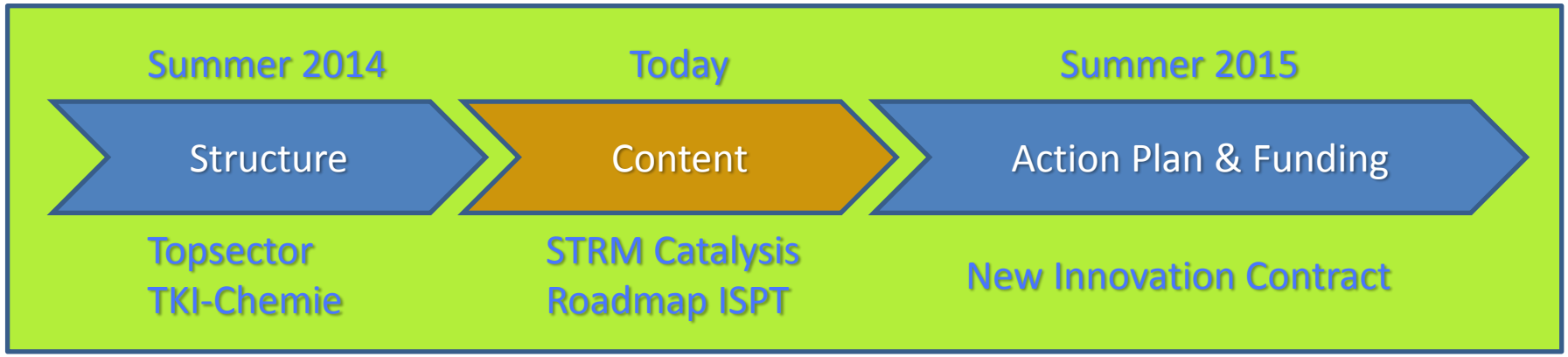






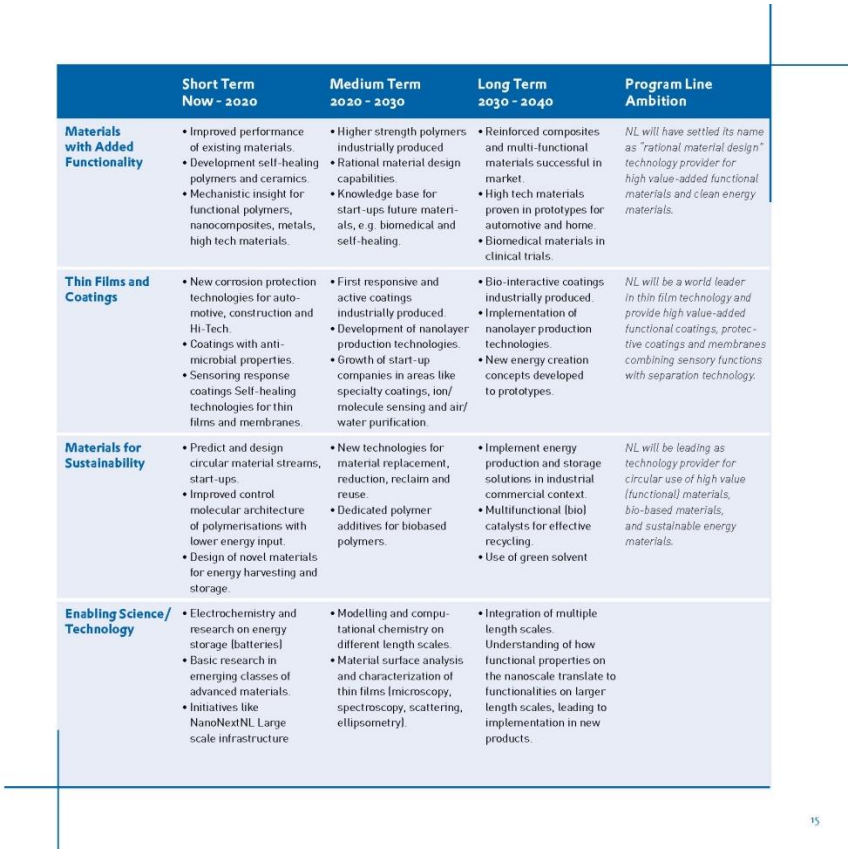
The next steps

- Implement roadmap in new TKI-Chemistry
- Integrate with Process Technology
- Translate into three-staged action plan and new science agenda
  - Now-2020
  - 2020-2030
  - 2030-2040



Knowledge and Innovation Agenda

Executive Summary Roadmap "Chemistry of Advanced Materials"



	Short Term Now - 2020	Medium Term 2020 - 2030	Long Term 2030 - 2040	Program Line Ambition
Materials with Added Functionality	• Improved performance of existing materials. • Development self-healing polymers and ceramics. • Mechanistic insight for functional polymers, nanocomposites, metals, high tech materials.	• Higher strength polymers industrially produced • Rational material design capabilities. • Knowledge base for start-ups future materi-als, e.g. biomedical and self-healing.	• Reinforced composites and multi-functional materials successful in market. • High tech materials proven in prototypes for automotive and home. • Biomedical materials in clinical trials.	*NL will have settled its name as "rational material design" technology provider for high value-added functional materials and clean energy materials.*
Thin Films and Coatings	• New corrosion protection technologies for auto-motive, construction and Hi-Tech. • Coatings with anti-microbial properties. • Sensoring response coatings Self-healing technologies for thin films and membranes.	• First responsive and active coatings industrially produced. • Development of nanolayer production technologies. • Growth of start-up companies in areas like specialty coatings, ion/ molecule sensing and air/ water purification.	• Bio-interactive coatings industrially produced. • Implementation of nanolayer production technologies. • New energy creation concepts developed to prototypes.	*NL will be a world leader in thin film technology and provide high value-added functional coatings, protec-tive coatings and membranes combining sensory functions with separation technology.*
Materials for Sustainability	• Predict and design circular material streams, start-ups. • Improved control molecular architecture of polymerisations with lower energy input. • Design of novel materials for energy harvesting and storage.	• New technologies for material replacement, reduction, reclaim and reuse. • Dedicated polymer additives for biobased polymers.	• Implement energy production and storage solutions in industrial commercial context. • Multifunctional (bio) catalysts for effective recycling. • Use of green solvent	*NL will be leading as technology provider for circular use of high value (functional) materials, bio-based materials, and sustainable energy materials.*
Enabling Science/ Technology	• Electrochemistry and research on energy storage (batteries) • Basic research in emerging classes of advanced materials. • Initiatives like NanoNextNL Large scale infrastructure	• Modelling and compu-tational chemistry on different length scales. • Material surface analysis and characterization of thin films (microscopy, spectroscopy, scattering, ellipsometry).	• Integration of multiple length scales. Understanding of how functional properties on the nanoscale translate to functionalities on larger length scales, leading to implementation in new products.	

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- Artificial materials are the cornerstone of our global society. Progress in the field of materials chemistry has enabled numerous new technologies and applications ever since the Stone Age, and will continue to do so in the coming decades.
- The Netherlands has a very strong position in various fields of advanced materials, and has a high ambition level for extending on this position;
- in the period 2030-2040, The Netherlands will have settled its name globally as "rational material design" technology provider for high value-added materials and clean energy materials

Executive Summary Roadmap "Chemistry of Life"

	Short term Now-2020	Mid term 2020-2030	Long term 2030-2040	Programme Line Ambition
Molecular entities, devices and approaches for understanding, monitoring and improving personalized health	• Personalized panomic analysis • Multidisciplinary multi-center of Drug Discovery • Understanding material properties contributing to improved compatibility in human cells.	• Target identification for (multifactorial) diseases • Structural information on the interaction of NCEs and bio-conjugates with target proteins • Explore new functionalities of materials in human bodies (e.g. stability, release, mechanical strength, lubrication, antimicrobial).	• Development of novel clinically affordable disease-ortented workflows and devices • Development of NCEs and bio-conjugates for use in diagnostics, in vivo imaging, and clinical applications • Piloting and commercialization of new materials and devices	*Improved and more affordable personalized health*
Molecular entities, technologies and approaches for understanding, monitoring and improving food (security)	• Molecular understanding of factors impacting texture/taste • Validated biomarkers of health and disease in order to come from descriptive models to predictive models • Identification of new, sustainable sources for protein supply	• Novel enzymes/microbes that tailor texture/taste both in situ and ex-situ • Quantitative and mechanistic models of in vitro and in vivo digestion of foods based on biochemical properties of food constituents • Novel biochemical processes for obtaining ingredients with reduced environmental footprint	• New, biochemically derived health promoting substances, including enzymes and micro-organisms • Correlation of in vitro and in vivo models • Novel ingredients to replace current, undesired food additives that are used to reduce spoilage	*Improved and more sustainable food*
Enabling technologies and approaches for fundamental understanding, monitoring and improving molecular entities in the Chemistry of Life	• Insight in the impact of the heterogeneity of proteins and protein complexes on cellular networks • Multidisciplinary center of Synthetic biology • Long term Public Private Partnership Programme on Building Blocks of Life	• Influence of heterogeneity in the dynamics of bio molecular networks and on the robustness of systems • Minimal cells that conduct specific bio-chemical reactions in a robust manner and that can be used in industrial applications related to bioenergy, biomaterials, chemical production	• Utilize the knowledge on network dynamics and cellular heterogeneity to tackle main societal challenges • Synthetic cell that in a controlled manner carries out basic biochemical reactions and that can replicate • "Organ-on-a-Chip" modules that can be used as a disease specific screening platform	*Accurate cell systems for medical and energy applications*

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- Understanding of Life on a molecular level (Chemistry of Life) provides a key that unlocks unlimited opportunities for breakthrough innovations, needed to address our global challenges for people today, and generations to come.
- The unifying aim in Chemistry of Life is therefore to bring about the chemical means and molecular understanding leading to an improved (precise), more and more personalized healthcare as well as more sustainable and healthy food for the benefit of mankind.

Executive Summary Roadmap

"Chemical Nanotechnology & Devices"

	Short Term Now - 2020	Medium Term 2021 - 2030	Long Term 2031 - 2040
Well-being **3.1.1 Bio-active sensing and actuation devices**	• In the lab • Avoid adverse reactions • Single analytediagnostics	• On the body / near the person • Bio-mimetic devices • Panel of analytes • Early diagnostics / monitoring	• In the body • Bio-controlling devices • Comprehensive biochemical profile • Precision medicine • Closed-loop monitoring and treatment
3.1.2 Human model systems on a chip	• Biomembrane on chip • Organ(elle) on chip (liver, heart, lung, etc.) • Cell on chip • Multicellular system on chip	• Organ functionality on a chip • Combination of organs • Interacting organs -- mimic complex	• Body function • High throughput screening technology
3.1.3 Microfluidic devices for synthesis and formulations in medicine and food	• Existing active ingredients and targeting formulations and encapsulates	• New active ingredients and formulations concepts • Biologics by cascade reactions	• Integrated and flexible production of formulated drugs -custom-made rational-designed nanomedicines
Cradle to Cradle **3.2.1 Resource Efficiency and closed value added chains (gate-to-gate) material and energy flows**	High efficient and sustainable (bio) catalyst embedded in flow-reactors.	Proof of concept for low energy, resource efficient and waste less chemical flow process, including up-stream and downstream processing, towards final product	Operational "Factory of the Future" on basis efficient use of energy and resources, without waste-streams lacking economic value
3.2.2 Time To market, speed-up of the process development	Novel multi-model analytical technologies with ultimate chemical resolution, at lowest possible length and different time scales	Availability of innovative micro-flow reactor technologies for gas-, liquid- and solid-phase chemistry. Advances in molecular, process modelling and statistics	Implementation of the "factory of the Future" on basis of "flow chemistry" in variety of chemical production processes
3.2.3 Process Reliability & Unification	Novel multi-model analytical technologies (integration of micro- and spectroscopic tools) for product characterization	Implementation of advanced computational methodologies for process modelling and advanced chemometrics supporting.	Reliable industrial production (implementation of PAT approach) of a large variety of smart and complex chemicals, materials, on basis of flow chemistry (3D printing), e.g. chemical modified (personalized) biopharma-ceuticals, food application
Energy **3.3.1 Electro-chemical reduction of CO_2 with minimum over-potential**	• New technology for efficient electrochemical catalysis	• Solar catalysis (water splitting)	• Energy production and storage at point of use
3.3.2 Towards a third generation solar cell	• Development of new nano-materials for solar cells	• Scalable synthesis routes • Scaling up of material production • Integrated in the material development process	• Solar cell device development and optimization

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- The roadmap "Chemical Nanotechnologies & Devices" refers to technologies and devices able to mimic, measure and sense (bio) chemical processes and is as such of crucial importance for the majority of the top sectors (Water, Life Sciences and Health, Agriculture & Food, Energy), and the top sector Chemistry in particular.
- From a technological point of view and envisioning a society in 2040, having free access to "personalized diagnostic sensors", the "factory of the future" and " sunlight as primary energy source", extensive technological breakthroughs in chemical, spatial (sub nm length scales) and temporal resolution are regarded vital.

Programmaraad

Chemical Conversion, Process Technology & Synthesis

- Prof. Dr. Eelco Vogt (Albemarle/UU), voorzitter
- Prof. Dr. Ir. Hans Kuipers (TU/e), vice-voorzitter

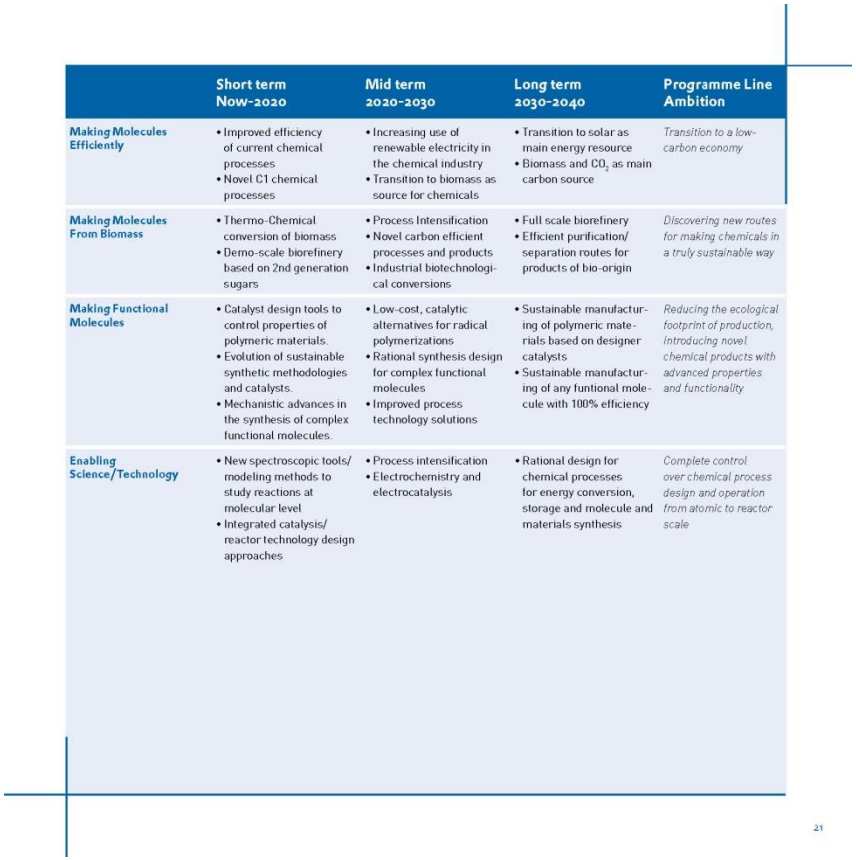
- Programmamanager: Dr. Arlette Werner

- Dr. Rinus Broxterman (DSM)
- Dr. Piet Huizenga (Shell)
- Ir. Peter Jansen (Corbion)
- Dr. Ed de Jong (Avantium)
- Dr. Sigrid Bollwerk (ECN)
- Dr. Robert Terörde (BASF)
- Dr. Dirk Verdoes (TNO)
- Dr. Ton Vries (Syncom)

- Prof. Dr. Gerrit Eggink (WUR)
- Prof. Dr. Syuzanna Harutyunyan (RUG)
- Prof. Dr. Emiel Hensen (TU/e)
- Prof. Dr. Bert Klein Gebbink (UU)
- Prof. Dr. Mark van Loosdrecht (TUD)
- Prof. Dr. Floris Rutjes (RUN)

Executive Summary Roadmap

"Chemical Conversion, Process Technology & Synthesis"



	Short term Now-2020	Mid term 2020-2030	Long term 2030-2040	Programme Line Ambition
Making Molecules Efficiently	• Improved efficiency of current chemical processes • Novel C1 chemical processes	• Increasing use of renewable electricity in the chemical industry • Transition to biomass as source for chemicals	• Transition to solar as main energy resource • Biomass and CO_2 as main carbon source	*Transition to a low-carbon economy*
Making Molecules From Biomass	• Thermo-Chemical conversion of biomass • Demo-scale biorefinery based on 2nd generation sugars	• Process Intensification • Novel carbon efficient processes and products • Industrial biotechnological conversions	• Full scale biorefinery • Efficient purification/ separation routes for products of bio-origin	*Discovering new routes for making chemicals in a truly sustainable way*
Making Functional Molecules	• Catalyst design tools to control properties of polymeric materials. • Evolution of sustainable synthetic methodologies and catalysts. • Mechanistic advances in the synthesis of complex functional molecules.	• Low-cost, catalytic alternatives for radical polymerizations • Rational synthesis design for complex functional molecules • Improved process technology solutions	• Sustainable manufacturing of polymeric materials based on designer catalysts • Sustainable manufacturing of any funtional molecule with 100% efficiency	*Reducing the ecological footprint of production, introducing novel chemical products with advanced properties and functionality*
Enabling Science/Technology	• New spectroscopic tools/ modeling methods to study reactions at molecular level • Integrated catalysis/ reactor technology design approaches	• Process intensification • Electrochemistry and electrocatalysis	• Rational design for chemical processes for energy conversion, storage and molecule and materials synthesis	*Complete control over chemical process design and operation from atomic to reactor scale*

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Overall Ambition:

To make the transition from our fossil resource dependent economy to a circular low-carbon economy that relies on sustainable and abundant resources.

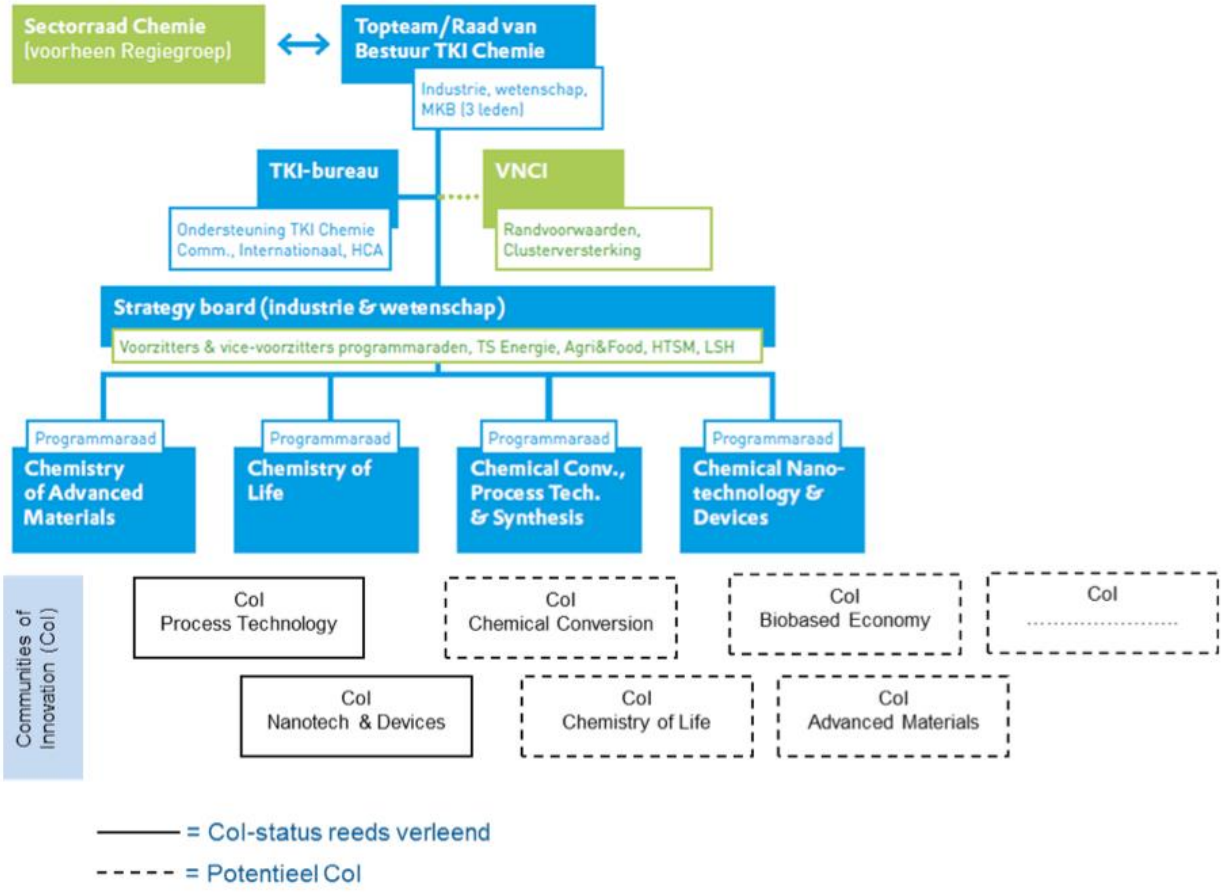
- The anticipated transition involves a three-pronged approach.
- Step improvements in the efficiency of current chemical processes are needed to decrease energy and raw material consumption.
- In the short term, new sustainable resources such as biomass for the manufacture of chemical products will require new combinations of designer catalysis and advanced process technology, in fields such as C_1-chemistry, waste recycling, and novel processes for the separation, purification and conversion of biomass.
- Integration of renewable energy in the form of electricity is a medium term challenge to enable the desired long-term transition to a circular economy in which materials and CO_2 recycle are key elements.
- Synthesis routes for complex functional molecules need to be developed that allow sustainable production of any functional chemical product in a minimum of process steps and with 100% efficiency.

How to reach these ambitions?

- The **Innovation Fund Chemistry** (the former Fund New Chemical Innovations) intends to promote cooperation and transfer of knowledge between **universities and companies**.
- The Innovation Fund Chemistry welcomes new initiatives that fit within the **roadmaps** of the Topsector Chemistry. **Verification of the fit** ("passendheidstoets") is carried out by the TKI Chemistry.
- ARC CBBC
  - (Next slides)

- **Funding tools Innovation Fund**
- **KIEM** (Knowledge Innovation Mapping): short-term initiatives in which SMEs together with universities and/or HBO-institutions can tackle a practical research question.
- **LIFT** (Launchpad for Innovative Future Technology): initiatives of at least one company and at least one knowledge institute in which the research question of the company is conducted and financed in two phases.
- **TA** (Technology Area): initiatives of consortia of at least two companies and at least two knowledge institutes in which the research questions of the participating companies are addressed coherently.
- **CHIPP** (Chemical Industrial Partnership Programme): initiatives of at least one company and at least two knowledge institutes focused strongly on research questions of the company.

TKI-Chemistry



Chemical Building Blocks Consortium

- Press release December 7:

  AkzoNobel, BASF, Shell, the Ministry of Economic Affairs, Top Sector Chemistry, the Netherlands Organisation for Scientific Research (NWO) and Utrecht University, the Eindhoven University of Technology and Groningen University today presented their plans for setting up the new Advanced Research Center Chemical Building Blocks Consortium (ARC CBBC).

  This national research centre will tackle important energy and chemistry issues associated with the growing depletion of the finite supply of raw materials.

  The partners have made a commitment for several years and are aiming to jointly invest EUR 11 million a year, or 80 - 100 jobs in the knowledge industry. "This will also reinforce our competitive position," Economic Affairs Minister Henk Kamp points out. "It will promote economic growth and generate new jobs."

Advanced
Research Center
Chemical Building
Blocks Consortium

ARC-CBBC: founding fathers

- Three Companies

- Three Universities

Two parts

- Proprietary Program
- Only accessible for the founding companies
- Bilateral programs, not limited to founding universities

- Fundamental Research and Valorization

- Open program
- Ticketing system

- Multi party programs
  - Open to other companies
  - Open to other universities

- Fundamental research

ARC-CBBC

- Ambition:
  - 10 year program at 10 million Euro per year level
  - This is mostly new money
  - Focal points in line with Roadmap CCPT&S
    - E.g., electrification, C_1-C_2-chemistry
    - Homogeneous, Heterogeneous Catalysis, Process Technology Advanced materials

- Next steps
  - Finalization of Consortium Agreement
  - Founding meeting end of this week
  - Symposium Early May (most likely May 10)

Communities of Innovation

- Within the Topsector Chemistry, Communities of Innovation (CoI's) unite and represent companies and knowledge institutes in a specific chemical discipline to stimulate local focus and excellence.
- A CoI initiates public-private research initiatives in the discipline. The CoI's target the creation of synergy and symbiosis within a discipline.
- At this point in time, the Topsector Chemistry recognizes two CoI's (Process Technology and Nanotech & Devices)

CoI's: Communities of Innovation