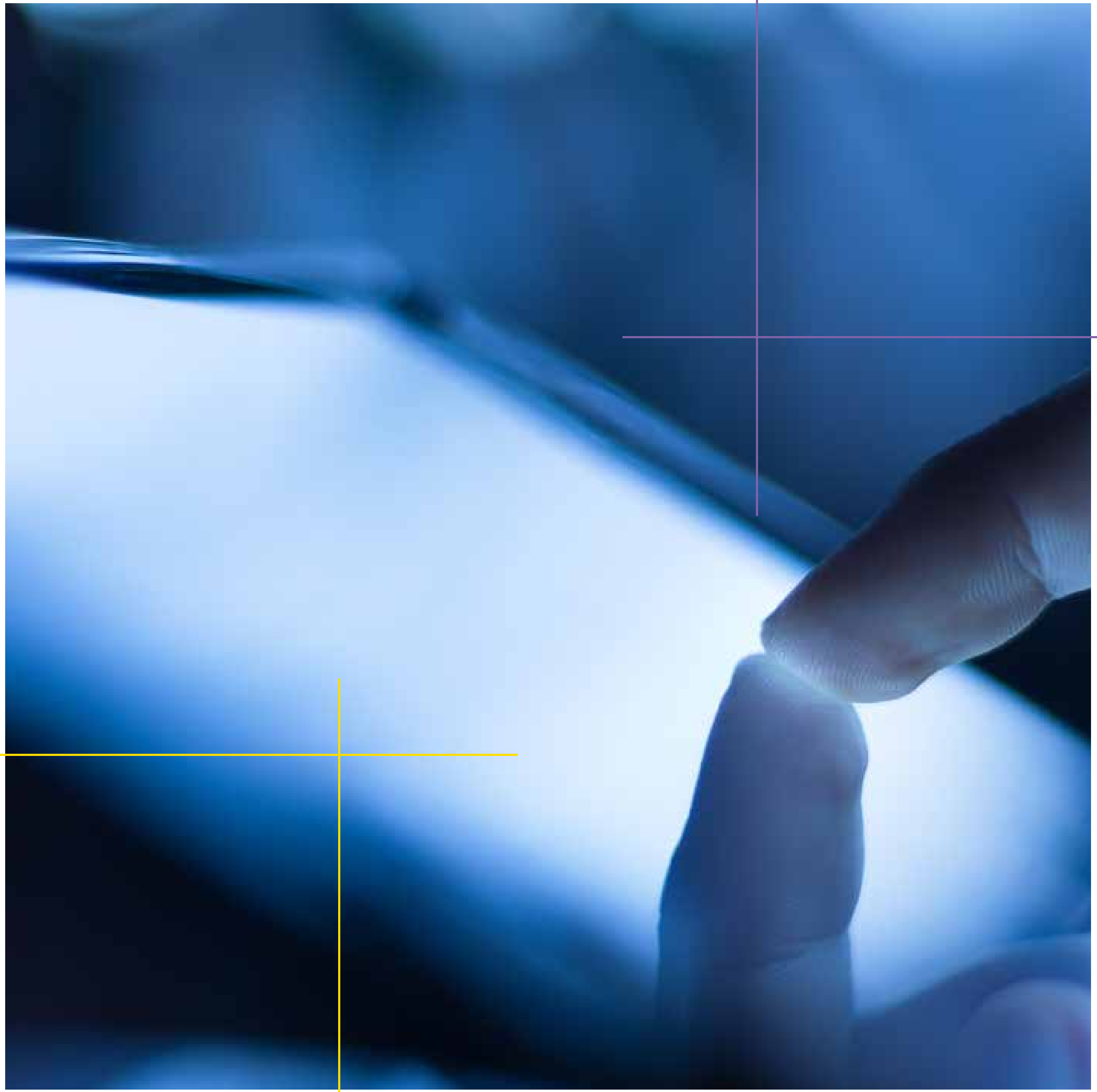
Topsector Chemie

Executive summary Kennis- en Innovatieagenda 2016-2019



Inhoud

De volledige Kennis- en Innovatieagenda 2016-2019 is te downloaden op:
www.topsectorchemie.nl/kia

1 Ambitie van de Topsector chemie

De Nederlandse chemie behoort industrieel en wetenschappelijk gezien tot de wereldtop.

Als maaksector draagt de chemie op een unieke manier bij aan vooruitgang in de welvaart en maatschappij. De kwaliteit van het onderzoek is uitstekend, de producten zijn hoogwaardig en innovatief en de sector is wat betreft efficiëntie en effectiviteit zeer concurrerend. De chemische sector is voor Nederland van groot belang met ruim € 60 miljard omzet, 62.000 werknemers (8% van de totale industrie in Nederland), € 77 miljard exportwaarde (18% van de Nederlandse export) en € 1 miljard aan R&D-uitgaven (23% van de totale industriële R&D-uitgaven in Nederland)[1].

[1] Feiten en cijfers van de Nederlandse chemische industrie in 2012 (zie www.vnci.nl).

De chemie onderscheidt een breed spectrum aan wetenschappelijke chemische subdisciplines die samen van groot belang zijn voor het innovatievermogen en de productie van bedrijven in veel andere sectoren. Met zijn bulk- en speciaalchemie is de sector in staat grondstoffen te verwaarden voor voedingsingrediënten, medicijnen en innovatieve materialen. Door die positie aan de basis van diverse waardeketens heeft de chemiesector ook een gedeelde **sleutelpositie** met sectoren als Energie en Agri&Food in de transitie naar een duurzame samenleving met een circulaire economie.

Naast toenemende concurrentiedruk hebben de bedrijven te maken met majeure veranderingen in de vraag in opkomende en ontwikkelde markten. Sommige producten moeten in de buurt van de afnemer worden geproduceerd en weer andere juist dichtbij de aanvoerbasis. Chemiebedrijven moeten daarom hun productieproces herinrichten als een optimaal functionerend ecosysteem. Dat ecosysteem loopt van grondstof, aanvoer, en verwaarding tot aan de gebruiker of afnemer.

Nieuwe maatschappelijke en wetenschappelijke ontwikkelingen dwingen ook wereldwijde veranderingen af in onderwijs, onderzoek en innovatie. De grenzen vervagen tussen landen, disciplines, wetenschap en industrie; en tussen fundamenteel en toegepast onderzoek.

Om de concurrentiedruk te pareren en op de veranderingen in te spelen heeft de chemische sector in Nederland ambitieuze doelstellingen geformuleerd. Die moeten de sector in staat stellen het innovatievermogen en het verdienvermogen beter te benutten. Ook dagen zij de sector uit in te spelen op **de geweldige kansen die de grote maatschappelijke uitdagingen van deze tijd bieden**.

De Nederlandse chemische wetenschap en industrie zijn gezamenlijk in staat antwoorden te formuleren op zaken zoals schaarste aan grondstoffen, voedsel en schoon water, de toename van de wereldbevolking, verstedelijking, energieverbruik en afvalstromen. Juist doordat de chemie aan het begin staat van diverse waardeketens, bieden de grote maatschappelijke uitdagingen kansen: **als maaksector zijn er nieuwe markten te winnen**.

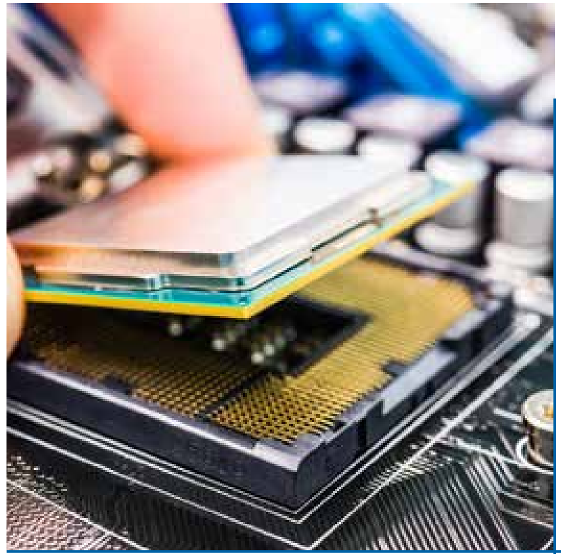
De Topsector Chemie heeft zich de volgende drie ambitieuze doelen gesteld:

- In 2050 staat Nederland wereldwijd bekend als hét land van de **groene en duurzame chemie**.
- In 2050 staat Nederland in de mondiale top 3 van producenten van **slimme materialen** met een hoge toegevoegde waarde en **slimme oplossingen**.
- Via **hoogwaardig grensverleggend wetenschappelijk onderzoek** in Nederland worden nieuwe gebieden van wetenschap en innovatie ontsloten.

Om deze doelen te bereiken stimuleert de Topsector innovatie en samenwerking tussen bedrijven en kennisinstellingen langs vier hoofdlijnen:

- **Chemistry of Advanced Materials**
- **Chemistry of Life**
- **Chemical Conversion, Process Technology & Synthesis**
- **Chemical Nanotechnology & Devices**

Deze hoofdlijnen zijn gebaseerd op maatschappelijke uitdagingen, industriële sterktes en de wetenschappelijke kennisbasis. Het zijn gebieden waarop Nederland het verschil maakt, waarbinnen innovaties waardevolle nieuwe producten kunnen opleveren, en waarbinnen een bijdrage kan worden geleverd aan verschillende (internationale) maatschappelijke uitdagingen.



2 Vier hoofdlijnen, vier programmaraden

De Topsector heeft voor elk van de vier hoofdlijnen een programmaraad ingesteld, bestaande uit vertegenwoordigers van bedrijfsleven en kennisinstellingen. Zie voor de samenstelling van de **programmaraden** appendix 1.

De programmaraden:

- spelen een actieve rol bij het tot stand komen en coördineren van nieuwe initiatieven binnen hun werkveld;
- adviseren de Topsector over relevante strategische thema's binnen hun werkveld, onder andere door het opstellen van een Roadmap;
- adviseren de Topsector over de passendheid van programma- en projectinitiatieven en bewaken zo de coherentie van de topsector-activiteiten op het gebied van kennis en innovatie;
- zorgen voor voldoende breedte in de aard en type van het publiek-private onderzoek.

De voorzitters en vicevoorzitters van de programmaraden maken deel uit van de Strategy Board.

In de eerste helft van 2015 hebben de programmaraden de hoofdlijnen uitgewerkt in roadmaps. Tijdens het schrijfproces hebben de programmaraden contact gehouden met en input gevraagd aan bestaande communities en andere achterbannen. Appendix 2 geeft een overzicht van de bedrijven die reeds betrokken zijn bij de Topsector Chemie. Zij nemen deel aan lopende publiekprivate projecten en programma's die zijn voortgekomen uit de vorige innovatieagenda van de Topsector Chemie.

Executive summaries van de roadmaps staan op bladzijde 12 tot en met 23.

De programmaraden en de Strategy Board zijn organen van het Topconsortium voor Kennis en Innovatie Chemie (TKI Chemie). Het TKI Chemie is de organisatie die uitvoering geeft aan de strategie van het Topteam Chemie en daarvoor ook input levert, zoals via de roadmaps.

3 Multidisciplinaire en cross-sectorale samenwerking

Chemie is een belangrijke enabler voor tal van andere industrieën en sectoren. Multidisciplinaire en cross-sectorale samenwerking en samenwerking in en over de kennisketen en ketens van toeleveranciers, producenten en afnemers behoren tot het wezen van de chemie. In elk van de roadmaps wordt in detail ingegaan op deze samenwerking.

De roadmaps zijn opgesteld langs de vier hoofdlijnen. Vanzelfsprekend zijn enabling sciences en technologies zoals modelleren, computationele chemie & spectroscopie, complexity, chemometrie en analytische chemie, van groot belang om de in de roadmap genoemde onderwerpen met succes te kunnen aanpakken.

De Topsector Chemie onderscheidt twee belangrijke cross-sectorale prioriteiten: **biobased economy** en **resource efficiency**. Voor biobased economy bestaat een apart Topconsortium voor Kennis en Innovatie: het TKI BBE. Het TKI BBE is uit de aard van de thematiek die het behartigt cross-sectoraal; het doorsnijdt de topsectoren Agri&Food, Energie en Chemie. Bestuurlijk staat het TKI BBE onder verantwoordelijkheid van het Topteam Chemie.

De BBE-aspecten die passen binnen de vier hoofdlijnen van de Topsector Chemie zijn geïntegreerd in de vier roadmaps van het TKI Chemie. Daarnaast is het streven naar grondstofefficiëntie geïntegreerd in de vier roadmaps. Het TKI BBE heeft in juni 2015 de "Onderzoeksagenda Biobased Economy 2015-2027" gepubliceerd.[2] Deze agenda is meegenomen in de totstandkoming van de vier roadmaps van het TKI Chemie.

Grafische samenvattingen van de belangrijkste relaties vanuit de vier chemie-roadmaps met andere topsectoren zijn te vinden op bladzijde 24 tot en met 29.

[2] http://www.kennisnetbiobased.nl/nl/biobasedeconomy/Strategie-beleid-en-visie/onderzoeksagenda.htm

4 Samenwerking met kennisinstellingen, regionale partners en de EU

Voor elk van de hoofdlijnen start de Topsector Chemie in 2016-2017 samen met kennispartners zoals NWO en TNO publiekprivaat gefinancierde programma's om uitvoering te geven aan de roadmaps. Het gaat hierbij niet alleen om programma's binnen Nederland, maar ook om Europese samenwerking en samenwerking met specifieke doellanden buiten Europa zoals China, de Verenigde Staten en Brazilië.

NWO stelt jaarlijks een bedrag beschikbaar aan de Topsector Chemie voor nieuwe PPS-initiatieven. De inzet voor 2016-2017 wordt in oktober 2015 vastgelegd in het innovatiecontract. Op verzoek van het Topteam zal NWO de succesvolle werkwijze met het Innovatiefonds Chemie (voorheen: Fonds Nieuwe Chemische Innovaties, Fonds NCI) voortzetten.[3] De kern van deze werkwijze is dat bedrijven en onderzoekers bottom-up nieuwe PPS-initiatieven tot stand brengen. De aanvragers dienen hun voorstellen in bij NWO; TKI Chemie toetst of ze passen binnen de roadmaps van de Topsector Chemie; NWO zorgt voor de beoordeling van de voorstellen op wetenschappelijke kwaliteit en het innovatiepotentieel, en besluit vervolgens tot honorering of afwijzing.

NWO zal de komende jaren ook geld voor een aantal grotere nationale en internationale programma's beschikbaar stellen.

Met **TNO** maakt de Topsector Chemie jaarlijks afspraken over de bijdrage die de organisatie kan leveren aan de uitvoering van de kennis- en innovatieagenda Chemie.

Het Topteam ziet tal van inhoudelijke raakvlakken met **ECN** en **DLO**, waarmee in een aantal programma's ook al wordt samengewerkt. Het is de ambitie om de samenwerking in de komende twee jaar verder uit te bouwen.

[3] www.nwo.nl/fondsnci en www.nwo.nl/ifc

De Topsector Chemie werkt intensief samen met alle **Nederlandse universiteiten** waar onderwijs wordt gegeven en onderzoek wordt gedaan in chemie en moleculaire wetenschappen. Het Topteam volgt met grote belangstelling de uitvoering van het Sectorplan Natuur- en Scheikunde, dat leidt tot structurele versterking van universitaire zwaartepunten. Een vervolgtraject in voorbereiding heeft de hartelijke steun van de Topsector, omdat voortgezette profilering van het universitaire onderzoek van essentieel belang is voor PPS.

Er zijn goede contacten met de chemische **HBO Centres of Expertise** (RDM Rotterdam, GreenPAC, Chemelot Innovation and Learning Labs (CHILL) en Centre of Expertise BBE Breda) en met het Domein Applied Sciences (DAS). De Topsector onderkent echter dat de samenwerking intensiever kan en neemt zich voor om daaraan de komende tijd te gaan werken. Om te beginnen zullen de banden met het Regieorgaan Praktijkgericht Onderzoek SIA worden aangehaald.

De samenwerking met **regionale partners** geeft de Topsector vorm via Innovatielabs (iLabs) en Centers of Open Chemical Innovation (COCI's).

De **Europese programmering** van Horizon2020 beidt vele mogelijkheden voor de Topsector. Op tal van thema's en onderwerpen wordt al vele jaren samengewerkt met Europese partners. Een aantal van deze samenwerkingsverbanden wil de Topsector versterken door middel van Nederlandse cofinanciering die via NWO beschikbaar wordt gesteld.

Grafische samenvattingen van de belangrijkste relaties vanuit de vier chemie-roadmaps met de Europese onderzoeksthema's zijn te vinden op bladzijde 30 t/m 32.

5 Brede participatie Midden- en Kleinbedrijf (MKB)

De Topsector Chemie heeft veel aandacht voor de participatie van het MKB. Onder de naam InnovatieLink hebben de Topsectoren Chemie en Energie hun krachten gebundeld voor een MKB-steunpunt.[4] InnovatieLink is in maart 2015 gestart en helpt MKB-bedrijven in de sectoren chemie en energie bij vragen en knelpunten op de weg van vinding naar markt.

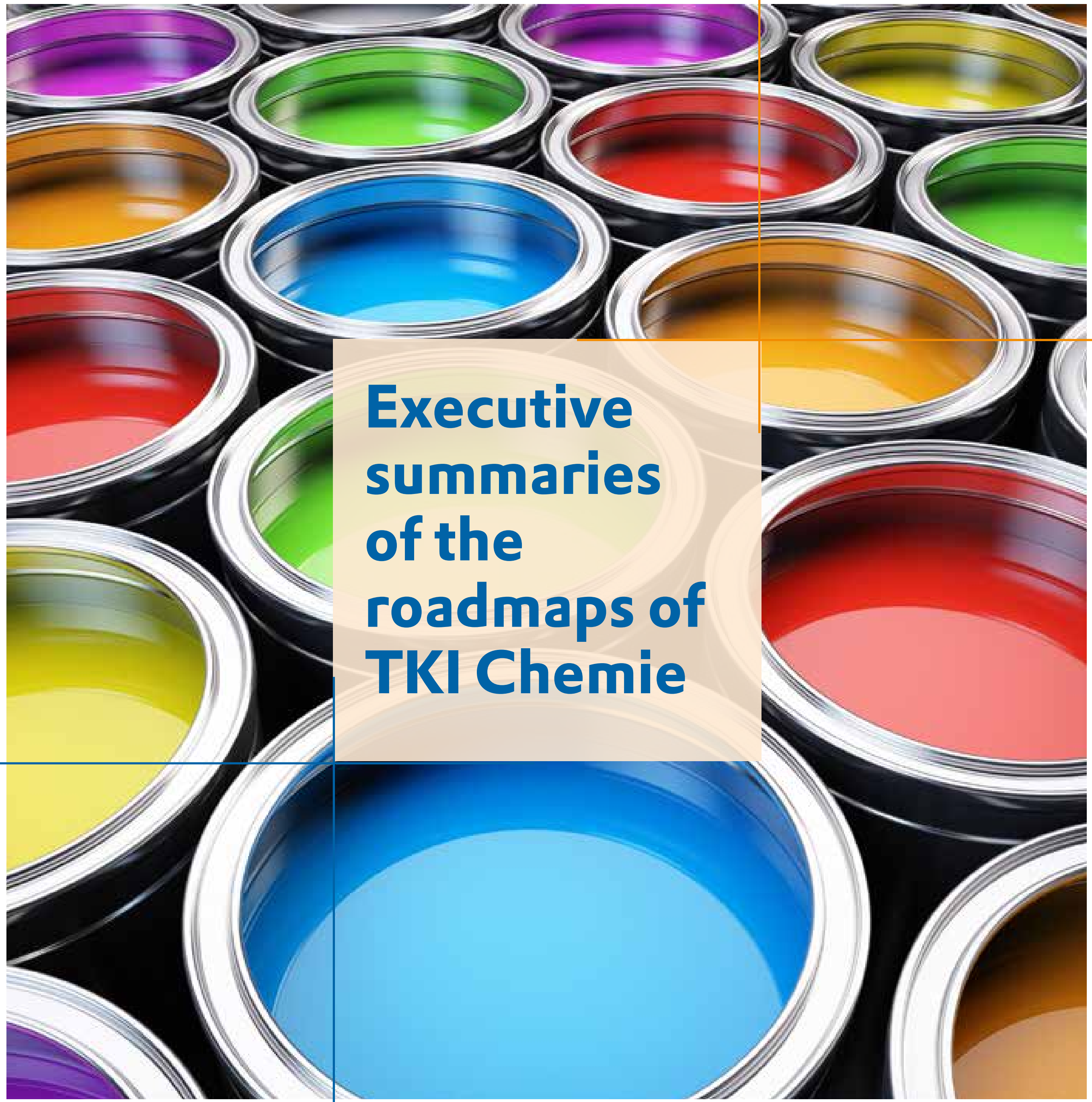
[4] www.innovatielink.nl

6 Organisatie Topsector Chemie

De Topsector Chemie wordt bestuurd door het Topteam Chemie. Het TKI Chemie ondersteunt het Topteam en voert de genomen besluiten uit. Het TKI heeft een lichte bureaustructuur en maakt gebruik van detacheringen vanuit het bedrijfsleven en bestaande onderzoeks-organisaties.

Het Topteam laat zich over ontwikkelingen in maatschappij, bedrijfsleven en wetenschap adviseren door een breed samengestelde Sectorraad. Op het gebied van kennis en innovatie spelen de Programmaraden en de Strategy Board een belangrijke rol.

Appendix 3 geeft een overzicht van de organisatie van de Topsector Chemie.



Executive summaries of the roadmaps of TKI Chemie

Executive Summary Roadmap

"Chemistry of Advanced Materials"

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.

In keeping with this long-term ambition level, the emphasis of materials chemistry research on the short term should be on mechanistic insight to be obtained for each of a plethora of desired functionalities and on the medium to long term on moving from increasing insight and understanding towards rational material design capabilities. For the latter, a broader scientific foundation of functionality of materials should be developed, including (predictive) modelling of formulations and properties.

The roadmap Chemistry of Advanced Materials has focused on three tasks: Materials with added Functionality, Thin films and Coatings, and Materials for Sustainability. All three tasks revolve around the key word "functionality" and prepare for a future in which advanced materials exert new functions, new combinations of functions, or true step-change improvements in their functions. Under the first task, the functionality is defined by the continuum (or "bulk") intrinsic properties of the materials, whereas surface effects dominate those properties under the second task. Under the third task, the functionality is related to sustainability. Either directly, when the material itself is made in a sustainable way, or indirectly, when the material enables sustainable energy harvesting or energy storage, reduction of energy consumption or requiring less (scarce) resources for production. Intrinsic design of advanced materials based on or allowing for circular economy or replacement of advanced materials with more sustainable alternatives is bridging task 3 with tasks 1 and 2. Of course, these three tasks are not mutually exclusive. The overall ambitions of each task and the specific steps that should be taken between now and 2040 are summarized on page 15.

This roadmap on the chemistry of advanced materials is mainly sustained by the Top sector Chemistry roadmap on Making Sustainable Chemical Products and the cross sectorial platform for Biobased Economy, by providing sustainable raw materials and (catalytic) technology for control of conversion of these raw materials into advanced materials. This connects to the EU Horizon 2020 theme of Resource Efficiency. In turn, the major beneficiaries of this roadmap are in the Top sector Chemistry roadmaps on Chemistry of Life (Biomedical Materials) and on Nanotechnology and Devices, as well as in the top sectors High-Tech Systems and Materials, Energy, and Water for applications of these advanced materials. These applications are fully in line with the EU Horizon 2020 themes Health, Energy, Transport, and Nutrition Security.

	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.	

Executive Summary Roadmap
"Chemistry of Life"

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.

Our life is dependent on molecules that enable, regulate, improve or threaten Life. During the past century scientific break-throughs led to the identification of molecules which are building blocks of life. We understand better and better their functions, how they interact with small molecules and how they contribute to life. This fundamental understanding is applied today in industry to develop products creating a better life for individuals and society as a whole.
While progress has been enormous, leading to novel and targeted medicine and securing our food supply for a growing population, we still face major gaps in understanding life on a molecular level, and we are still faced with great challenges in healthcare as well as a sustainable healthy food supply.

What are the next scientific breakthroughs in Chemistry of Life? How can The Netherlands contribute to these by using and further developing our excellent knowledge infrastructure and network of world class Universities, Knowledge Institutes and the private sector? How can we capture innovations and economic growth in The Netherlands based on these breakthroughs (e.g. expanding current vibrant biotech start-ups and establishing novel ventures)?

The answers will come from **collaborations**. Collaborations across disciplines, across industries (value chains), and across the world. The Chemistry of Life roadmap is therefore set up with a focus on molecular insights reaching out to (collaborating with) all sectors contributing to the scientific and economic breakthroughs the top sector wants to enable. These connections are further specified in section 4.

A three-pillar (task) roadmap has been developed to address the scientific challenges and economic opportunities in healthcare (task 1) and food/nutrition (task 2) and the link between them, connecting health and food/ nutrition.
The **first pillar** (task 1) focuses on 'Molecular entities, devices and approaches for understanding, monitoring and improving **personalized health**'.
Various human diseases are the result of altered or malfunctioning molecular/cellular mechanisms or genetic mutations. It is of utmost importance to understand the cellular wiring of the diseased state and develop (therapeutic) approaches to prevent this or reprogram and revert cells to a normal healthy state or to trigger cell death (apoptosis). Genomics, transcriptomics, proteomics, metabolomics data (omics, or panomics when integrated) from patient material, including the gut microbiota, constitute a treasure trove to understand and redirect molecular pathways. These pathways may be targeted by existing or newly developed drugs, thereby offering an avenue towards personalized medicine.
The **second pillar** (task 2) focuses on 'Molecular entities, devices and approaches for understanding, monitoring and improving **food security**'. Unraveling the precise mechanisms that govern molecular interactions is at the very heart of Chemistry of Life. The Netherlands has always been a stronghold with respect to recognizing the importance of the interaction of chemistry and chemical biology in the life science sector. Such a molecular understanding will also enable the food sector to get to the next level answering fundamental scientific questions to provide breakthrough innovations that address societal needs related to food quality and security throughout the whole lifespan.
The **third pillar** (task 3) creates a deeper **understanding of the building blocks of life** and developing **enabling technologies** while providing valuable input for understanding, monitoring and improving health and food security.

	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-oriented 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 biochemical 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*

Executive Summary Roadmap

"Chemical Conversion, Process Technology & Synthesis"

Making Sustainable Chemical Products

The roadmap of the program council "Chemical Conversion, Process Technology and Synthesis" addresses the grand challenge to transform our fossil-resource dependent economy into a low-carbon society that fully relies on sustainable and abundant resources. Innovations and breakthroughs in catalysis and process technology are recognized as key enabling technologies.

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 C1-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.

The desired breakthroughs that will drive these innovations require investments in fundamental science and technology. New spectroscopic tools will provide insight at molecular level, which will be combined with theory-based rational design of chemical processes and catalysts for the conversion and storage of energy, as well as for the synthesis of sustainable chemical products and materials. This will eventually lead to complete control over chemical process design and operation from atomic scale all the way up to reactor scale.

In order to reach the goals described in this roadmap, it will be necessary to invest in a concerted effort of considerable magnitude, for instance an **Advanced Research Center** (ARC) targeting chemical building blocks in the area of Catalysis, Process Technology and Synthesis, with a maximum impact for cooperating private and academic partners, and with international reputation. At the same time we should connect with regional initiatives. The envisioned scope would be a program of about 14 million euros per year for a period of ten years.

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.

	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*

Executive Summary Roadmap
"Chemical Nanotechnology & Devices"

Mimicking, Measuring & Sensing, key in creating an ultimate insight into Bio & Synthetic (inter & intra) molecular processes

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. In this roadmap, a focused and prioritized program comprising (bio)sensors, micro/nanofluidics, flow-(micro) reactors, analytical technologies with ultimate (chemical, spatial & temporal) resolution and the third generation solar cells is described. These technologies are an integral part of the three main tasks, **Well-being**, **Cradle to Cradle 2.0** and **Energy**, which are highly related to "**People**, **Planet** & **Profit**".

	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 formula-tions 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

Grafische samenvattingen roadmaps

Roadmaps TKI Chemistry – Top sector Chemistry

Chemistry of Advanced Materials

Task 1: Designing materials with the right functionality
- 1.1 Traditional materials [HTSM, Energy]
- 1.2 Multi-functional materials [HTSM, Energy, Creat.]
- 1.3 High-tech materials [HTSM, Energy, Creat. Ind.]
- 1.4 Biomedical materials [LSH, HTSM]

Task 2: Thin films and coatings
- 2.1 Traditional coatings, packaging films, and membranes [Agri&Food, HTSM, Energy, Water]
- 2.2 Multifunctional and responsive coatings and thin films [LSH, Agri&Food, HTSM, Water, Creat. Ind.]
- 2.3 Bio-(inter)active sensors, coatings and films [LSH, HTSM]
- 2.4 Coatings for energy creation/saving [Energy]

Task 3: Materials for sustainability
- 3.1 Replacement of petrochemical feedstocks by bio-based feedstocks [BBE]
- 3.2 Improved waste management by recycling of materials, re-use and recovery of product components and / or compound [Agri&Food, BBE, HTSM, Creative Ind.]
- 3.3 Sustainable materials for energy [BBE, Energy]

Chemistry of Life

Task 1: Molecular entities, devices and approaches for understanding, monitoring and improving personalized health
- 1.1 Development of analytical and biophysical devices [LSH, HTSM, Agri&Food]
- 1.2 Creation of new chemical, molecular and cellular entities [LSH]
- 1.3 Biomedical materials for improved functionalities

Task 2: Molecular entities, technologies and approaches for understanding, monitoring and improving food (security)
- 2.1 Biochemical tailoring of food [Agri&Food]
- 2.2 Understanding food digestion and metabolism to increase nutritional availability and health [LSH, Agri&Food]
- 2.3 Sustainable production and consumption [BBE, Agri&Food]

Task 3: Enabling technologies and approaches for fundamental understanding, monitoring and improving molecular entities in the Chemistry of Life

[LSH, Agri&Food, BBE, Energy]

Chemical Conversion, Process Technology and Synthesis

Task 1: Making molecules efficiently
- 1.1 Feedstock diversification: C1 chemistry [Energy]
- 1.2 Feedstock diversification: sustainable resources, solar, wind and others [BBE, Energy]
- 1.3 Efficiency in chemical production

Task 2: Making molecules from biomass
- 2.1 (Thermo-)chemical biomass conversion [BBE, Agri&Food, Energy]
- 2.2 Biomass conversion using industrial (white) biotechnology [BBE, Agri&Food, LSH, Energy]
- 2.3 Biorefining and circular economy [BBE, Agrii&Food, Energy, Water]

Task 3: Making functional molecules
- 3.1 High performance materials [Energy]
- 3.2 Speciality, pharma and fine chemicals [Agri&Food, LSH, HTSM]
- 3.3 Process technology for manufacturing functional molecules [HTSM]

Chemical Nanotechnology and Devices

Task 1: Well-being (Quality of life)
- 1.1 Bio-active sensing and actuation devices [LSH, HTSM, Water]
- 1.2 Human disease and organ model systems on a chip [LSH, Agri&Food, HTSM]
- 1.3 Microfluidic devices for synthesis and formulations in medicine and food [LSH, HTSM, Agri&Food]

Task 2: Cradle to cradle 2.0
- 2.1 Resource efficiency and closed value added chains (gate to gate) material and energy flows [HTSM, Energy, BBE]
- 2.2 Time to market speed up of the process development [LSH, HTSM]
- 2.3 Process reliability and unification [LSH, HTSM, Agri&Food]

Task 3: Energy efficiency and storage
- 3.1 Electrochemical reduction of CO_2 with minimum over-potential [HTSM, Energy]
- 3.2 Towards a third generation solar cell [HTSM, Energy, BBE]

Crossover with other roadmaps:
Link to Chemistry of Advanced Materials · Link to roadmap Chemistry of Life · Link to roadmap Chemical Conversion, Process Technology and Synthesis · Link to roadmap Chemical Nanotechnology and Devices

Connections/cross-overs roadmap
"Chemistry of Advanced Materials" with other roadmaps

Connections/cross-overs Roadmap Advanced Materials		TKI Chemistry of Life	TKI Chemistry: Chem Conversion, Process Tech, Synthesis	TKI Chemistry: Nano-technology and devices	TKI BBE	TS: Agri/Food	TS: LSH	TS: HTSM	ST: Energy	TS: Water	TS: Creative Industry
Task 1: Designing Materials with the Right Functionality	Traditional Materials		Yellow					Blue	Blue		
	Mult-Functional Materials		Yellow	Green				Green	Blue		Green
	High-Tech Materials		Yellow	Green				Green	Blue		Green
	Biomedical Materials	Green	Yellow	Green	Blue			Green			
Task 2: Thin Films and Coating	Traditional Coatings, Packaging Films and Membranes		Green	Green		Blue		Green	Blue	Blue	
	Multifunctional and Responsive Coatings and Thin Films			Green	Blue	Blue		Green		Blue	Blue
	Bio-(inter)active sensors, coating and films	Blue		Blue	Blue			Blue			
	Coatings for energy creation/saving	Green		Blue					Blue		
Task 3: Materials for Sustainability	Replacements of petrochemical feedstocks by bio-based feedstocks		Green			Yellow	Green				
	Improved waste management by recycling of materials, re-use and recovery of product components and/or compound		Blue	Blue		Blue	Yellow	Blue			Yellow
	Sustainable materials for energy		Green				Yellow		Blue		

Blue: *Roadmap Adv Mat facilitates development in connecting platform*
Yellow: *Roadmap Adv Mat benefits from development in connecting platform*
Green: *Roadmap Adv Mat and connecting platform both facilitate and benefit from activities*

Connections/cross-overs roadmap
"Chemistry of Life" with other roadmaps

Connections/cross-overs Roadmap Chemistry of Life		TKI Chemistry: Advanced Materials	TKI Chemistry: Chem Conversion, Process Tech, Synthesis	TKI Chemistry: Nano-technology and devices	TKI BBE	TS: Agri/Food	TS: LSH	TS: HTSM	ST: Energy
Task 1: Molecular entities, devices and approaches for under-standing, monitoring and improving personanilzed health	Development of analytical and biophysical devices			Green	Green	Blue		Green	
	Creation of new chemical, molecular and cellular entities		Green	Green	Blue				
	Biomedical Materials for improved functionalities	Yellow							
Task 2: Molecular entities, technologies and approaches for understanding, moni-toring and improving food (security)	Biochemical tailoring of food	Blue		Yellow		Blue			
	Increases nutritional availability				Blue	Blue			
	Sustainable production and consumption	Blue				Blue	Blue		Green
Task 3: Enabling technologies and approaches for funda-mental understanding, monitoring and improving molecular entities in the Chemistry of Life		Green		Yellow	Green	Green	Green	Green	Green

Blue: *Roadmap CoL facilitates development in connecting platform*
Yellow: *Roadmap CoL benefits from development in connecting platform*
Green: *Roadmap CoL and connecting platform both facilitate and benefit from activities*

Connections/cross-overs roadmap
"Chemical Conversion, Process Technology and Synthesis" with other roadmaps

Connections/cross-overs Roadmap Chemical Conversion, Proces Technology & Synthesis		TKI Chemistry: Advanced Materials	TKI Chemistry: Chemistry of Life	TKI Chemistry: Nano-technology and devices	TKI BBE	TS: Agri/Food	TS: LSH	TS: HTSM	ST: Energy	TS: Water
Task 1: Making Molecules Efficiently	Feedback diversification: C1-chemistry			Green					Blue	
	Feedstock diversification: Sustainable resources, Solar, Wind and others	Green		Green	Green				Green	
	Efficiency in chemical production			Yellow						
Task 2: Making Molecules from Biomass	(Thermo-)Chemical Biomass conversion				Green	Yellow			Blue	
	Biomass conversion using Industrial (White) Biotechnology		Blue		Green	Yellow	Blue		Blue	
	Biorefining and Circular Economy	Green			Green	Yellow			Blue	Green
Task 3: Making Functional Molecules	High performance materials	Green		Green					Green	
	Speciality, pharma and fine chemicals	Yellow	Green			Green	Blue	Green		
	Process technology for manufacturng functional molecules	Green	Yellow	Green				Yellow		

Blue: *Roadmap CCPT&S facilitates development in connecting platform*
Yellow: *Roadmap CCPT&S benefits from development in connecting platform*
Green: *Roadmap CCPT&S and connecting platform both facilitate and benefit from activities*

Connections/cross-overs roadmap
"Chemical Nanotechnology & Devices" with other roadmaps

Connections/cross-overs Roadmap Nanotechnology and Devices		TKI Chemistry: Advanced Materials	TKI Chemistry: Chemistry of Life	TKI Chemistry: Chem Conversion, Process Tech, Synthsis	TKI BBE	TS: Agri/Food	TS: LSH	TS: HTSM	ST: Energy	TS: Water	Horizon2020	TI Coast
Task 1: Well-being (Quality of Life)	Bio-active sensing and actuation devices	Green	Green			Yellow		Green		Blue	Green	Yellow
	Human disease and organ modelsystems on al chip		Green			Yellow	Blue	Green			Green	Yellow
	Microfludic devices for synthesis and formulations in medicine and food	Green	Green			Yellow	Blue	Green			Green	Yellow
Task 2: Cradle to cradle 2.0	Resource efficiency and closed value added chains (gate to gate) material and energy flows			Green	Green			Green	Green		Green	Yellow
	Time to market speed up of the process development	Green				Yellow		Green			Green	Yellow
	Process Reliability & Unification	Green		Blue		Yellow	Blue	Green			Green	Yellow
Task 3: Energy Efficiency and Storage	Electrochemical reduction of CO_2 with minimum over-potential	Blue	Yellow	Green				Green	Blue		Green	Yellow
	Towards a third generation solar cell	Blue			Blue			Blue			Green	Yellow

Blue: *Roadmap CN&D facilitates development in connecting platform*
Yellow: *Roadmap CN&D benefits from development in connecting platform*
Green: *Roadmap CN&D and connecting platform both facilitate and benefit from activities*

Relatie Topsector Chemie met Europese thema's:
Kansen voor de Topsector Chemie

Maatschappelijke uitdagingen: de zeven Europese uitdagingen, en de kernthema's uit de innovatie-agenda's van de topsectoren:

Thema 1 Gezondheid, demografische veranderingen en welzijn	
Thema's	**Topsectoren**
E-health; zelfmanagement; telegeneeskunde; IT infrastructuur; Domotica	LSH, Creatief, HTSM, Chemie, Energie
Moleculaire biologie; verouderingsbiologie; regeneratieve geneeskunde	LSH, A&F, Chemie, HTSM
Voeding en medicijnen op maat	LSH, A&F, Chemie, Creatief
Moleculaire en beelddiagnostiek	LSH, A&F, HTSM, Chemie
Medische instrumenten	LSH, HTSM, Chemie
Proefdieren	LSH, Chemie
Logistiek en zorg	LSH, Logistiek

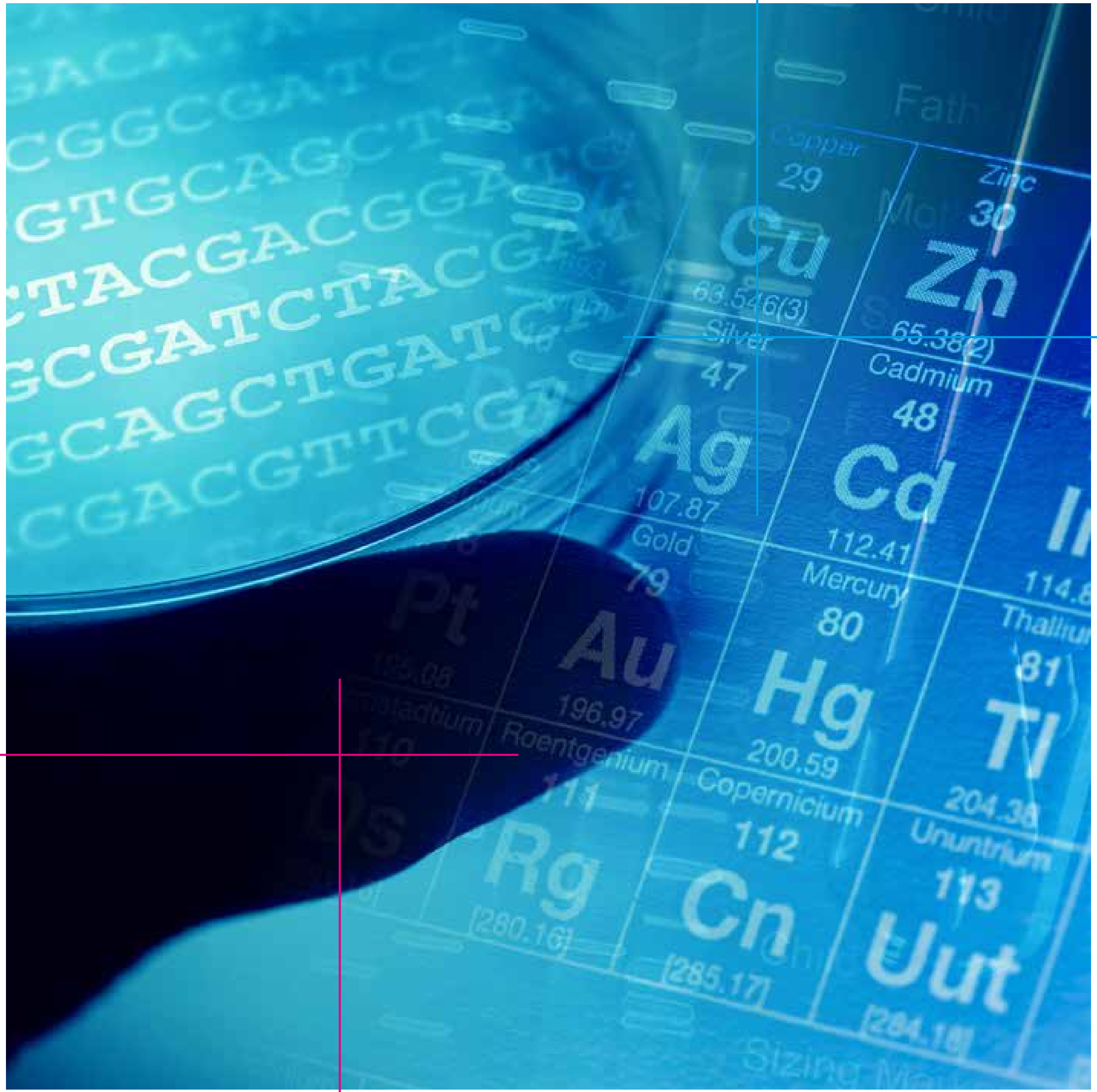
Thema 2 Voedselveiligheid, duurzame langbouw, marien en maritiem onderzoek en bio-economie	
Thema's	**Topsectoren**
Robuuste plantaardige productie	A&F, T&U, Chemie, Logistiek, Water, T&U
Duurzame veehouderij	A&F, LSH, Chemie
Voedselveiligheid superieure producten en processen	A&F, T&U, HTSM, Water, Chemie
Food & Health	A&F, LSH, T&U, Chemie
Consument en keten	A&F, Creatief, Logistiek, Chemie
BBE	Energie, Chemie, Agri&Food, T&U, Logistiek

Thema 3 Veilige, schone en efficiënte energie	
Thema's	**Topsectoren**
Urban Energy	A&F; Chemie; Water; T&U
Wind op zee	Creatief, T&U; Energie; Water; Chemie
Procestechnologie	Creatief, T&U; Energie; HTSM
Gas	Energie, Water
BBE	Energie; Water; Chemie

Thema 4 Klimaatmaatregelen, hulpbronnen efficiëntie, grondstoffen	
Thema's	**Topsectoren**
Duurzame deltasteden	Water, Creatief, Chemie, Logistiek, A&F, T&U
Watermanagement	Water, A&F, T&U, Chemie
Resource efficiency	Water, A&F, T&U, Logistiek, Creatief, Chemie, HTSM
Water en ict	Water, ICT

Thema 5 Slim, groen, geïntegreerd vervoer	
Thema's	**Topsectoren**
Ketenintegratie	Logistiek, A&F, T&U
Servicelogistiek, Synchromodaliteit	Logistiek, Energie, A&F, HTSM, Chemie
Elektrisch vervoer	Logistiek, Energie, HTSM
Aeronautics	HTSM, Chemie, Logistiek, Energie, Water
Automotive, components & circuits	HTSM, Logistiek, Energie, Chemie, Creatief
Schone Schepen	Water, Energie, Logistiek, Chemie
Effectieve, duurzame infrastructuur	Water, Logistiek, Chemie
Slimme schepen	Water, HTSM, Logistiek

Thema 6 Inclusieve, innovatieve en veilige samenlevingen	
Thema's	**Topsectoren**
Veilige en betrouwbare ICT	ICT, HTSM
ICT voor monitoring en controle	ICT, A&F, Chemie, Logistiek
Big Data	ICT, Energie, HTSM, LSH
ICT for a connected World	Logistiek



Appendix 1:
Samenstelling Programmaraden TKI Chemie

Chemistry of Advanced Materials
- Prof. dr. Rolf van Benthem (DSM/TU/e), vz
- Prof. dr. Andries Meijerink (UU), vice vz
- Dr. Irene Hamelers/Dr. Ivo Ridder (TKI Chemistry, Program Manager)
- Dr. Keimpe van den Berg (Akzo Nobel)
- Dr. Pascal Buskens (TNO)
- Prof. dr. Jeroen Cornelissen (UT)
- Prof. dr. Theo Dingemans (TUD)
- Dr. Harold Gankema (AFP Holland)
- Dr. ir. Han Goossens (TU/e)
- Dr. Jacco van Haveren (FBR)
- Prof. dr. René Janssen (TU/e)
- Prof. dr. Katja Loos (RUG)
- Dr. Jan Noordegraaf (Synbra Technology)
- Dr. Matthijs Ruitenbeek (DOW)
- Dr. Jaco Saurwalt (ECN)
- Dr. Rolf Scherrenberg (SABIC)

Chemistry of Life
- Dr. Oliver May (DSM), vz
- Prof. dr. Arnold Driessen (RUG), vice vz
- Dr. Marjolein Lauwen (TKI Chemistry, Program Manager)
- Dr. Peter van Dijken (TNO)
- Prof. dr. Stan van Boeckel (Pivot Park)
- Dr. Marco Giuseppin (AVEBE)
- Prof. dr. Harry Gruppen (WUR)
- Prof. dr. Albert Heck (UU)
- Prof. dr. Jan Knol (Danone)
- Prof. dr. Huib Ovaa (NKI)
- Prof. dr. Hermen Overkleeft (UL)
- Prof. dr. Martine Smit (VU)
- Leendert Wesdorp (Unilever)
- Dr. Martin Wijsman (FrieslandCampina)
- Prof. Claire Wyman (EUR)
- Dr. Daniel Zollinger (Okklo Life Sciences)

Chemical Conversion, Process Technology & Synthesis
- Prof. dr. Eelco Vogt (Albemarle), vz
- Prof. dr. ir. Hans Kuipers (TU/e), vice vz
- Dr. Arlette Werner (TKI Chemistry, Program Manager)
- Dr. Sigrid Bollwerk (ECN)
- Dr. Rinus Broxterman (DSM)
- Prof. dr. Gerrit Eggink (WUR)
- Prof. dr. Syuzanna Harutyunyan (RUG)
- Prof. dr. Emiel Hensen (TU/e)
- Dr. Piet Huizenga (Shell)
- Ir. Peter Jansen (Corbion)
- Dr. Ed de Jong (Avantium)
- Prof. dr. Bert Klein Gebbink (UU)
- Prof. dr. Mark van Loosdrecht (TUD)
- Prof. dr. Floris Rutjes (RUN)
- Dr. Robert Terörde (BASF)
- Dr. Dirk Verdoes (TNO)
- Dr. Ton Vries (Syncom)

Chemical Nanotechnology & Devices
- Ir. Benno Oderkerk (Avantes), vz
- Prof. dr. Albert van den Berg (UT), vice vz
- Dr. Jan de Vlieger (TKI Chemistry, Program Manager)
- Prof. dr. Arian van Asten (NFI, UvA)
- Dr. Marco Blom (Micronit)
- Prof. dr. Volker Hessel (TU/e)
- Prof. dr. Maarten Honing (DSM)
- Prof. dr. Michiel Kreutzer (TUD)
- Ir. Henk Leeuwis (LioniX)
- Michiel Oderwald (TNO)
- Prof. dr. Menno Prins (TU/e)
- Dr. Bennie Reesink (BASF)
- Prof. dr. Alan Rowan (RU)
- Prof. dr. Karin Schroën (WUR)

Appendix 2:
Bedrijven betrokken bij PPS in de Topsector Chemie

20Med Therapeutics
3DPPM

A
Abundnz
Airborne
Akzo Nobel Chemicals
Akzo Nobel Industrial Chemicals
Albemarle Catalysts Company
Amsterdam Scientific Instruments
Apollo Vredestein
Aquastill
Arizona Chemicals
Arkema
ASMI
ASML Netherlands
Aspen Pharmacare
Avantes
Avantium Technologies
Avantor Performance Materials
AVEBE
Avery Dennison

B
BaseClear
BASF Nederland
Bayer
Beckman Coulter Nederland
Beckman Coulter, Corporate Headquarters
Bender Analytical Holding
Bioclear
BioNovion
BioTools
Braskem

C
C4C Holding
Cambridge Major Laboratories
Cargill
ten Cate
ChemConnection
Chemtrix
Chemtura
Chiralix
Corbion Purac
Cosun
Cristal Therapeutics
Croda
Crossbeta Biosciences
Crucell
CytoBuoy

D
Danone
Da Vinci Europe Laboratory Solutions
DELMIC
Dionex Benelux
Dow Benelux
DSM Coating Resins
DSM Food Specialties
DSM Gist Services BV
DSM Innovative Synthesis
DSM R&D Solutions
DSM Resolve
DSM Resolve, Lifetec
Dupont
DutchSpace
Dyadic Nederland

E
Eastman
EFC
Elopak
Elson Technologies
Emultech
Enzypep
ETD&C
EuroProxima
Evorik
Excytex

F
Fokker
FrieslandCampina
Fuji Film
FutureChemistry

G
Galapagos
Generation of Change
Genmab
Geochem Research
Givaudan

H
HAL Allergy
Heineken Supply Chain
Heinz
Huntsman

I
ICL
INTEGREX Research
Ionicon Analytik

J
Johnson Matthey Catalysts

K
Katwijk Chemie
KNN
Krehalon

L
Lanxess
Latexfalt
Lionix
Lucite International UK

M
Maastricht Instruments
Magneto Chemie
Materiomics
MercaChem
Micronit Microfluidics
Mimetas
Momentive
MSD
MTSA

N
Naturalis Biodiversity Center
Nestlé
Netherlands Translational Research Center
Norit
NovioSmart
NovioTech
Nuplex
NXP

O
Océ
Octoplus
Oerlemans Plastics
Okklo Life Sciences
Omics2Image

P
Pansynt
Paques
Pepscope
Pervatech
Philips Medical Systems
PPG

S
SABIC
Sachem
Sasol
Scientific Computing & Modelling
Shell Global Solutions International
Shell Research and Technology Centre
Simadan
SKF
SoliQz
Solliance
SolSep
Solvay
Spinld/FlowID
Spinnovation Analytical
Stichting Waterproef
Surface Preparation Laboratory
Surfix
SyMo-Chem
Synbra
Syncom
Syngenta
Synthon

T
Tata Steel
Technex (with associated partner BioNavis)
Technobis
Technoforce
Teijin Aramid
TropIQ Health Sciences

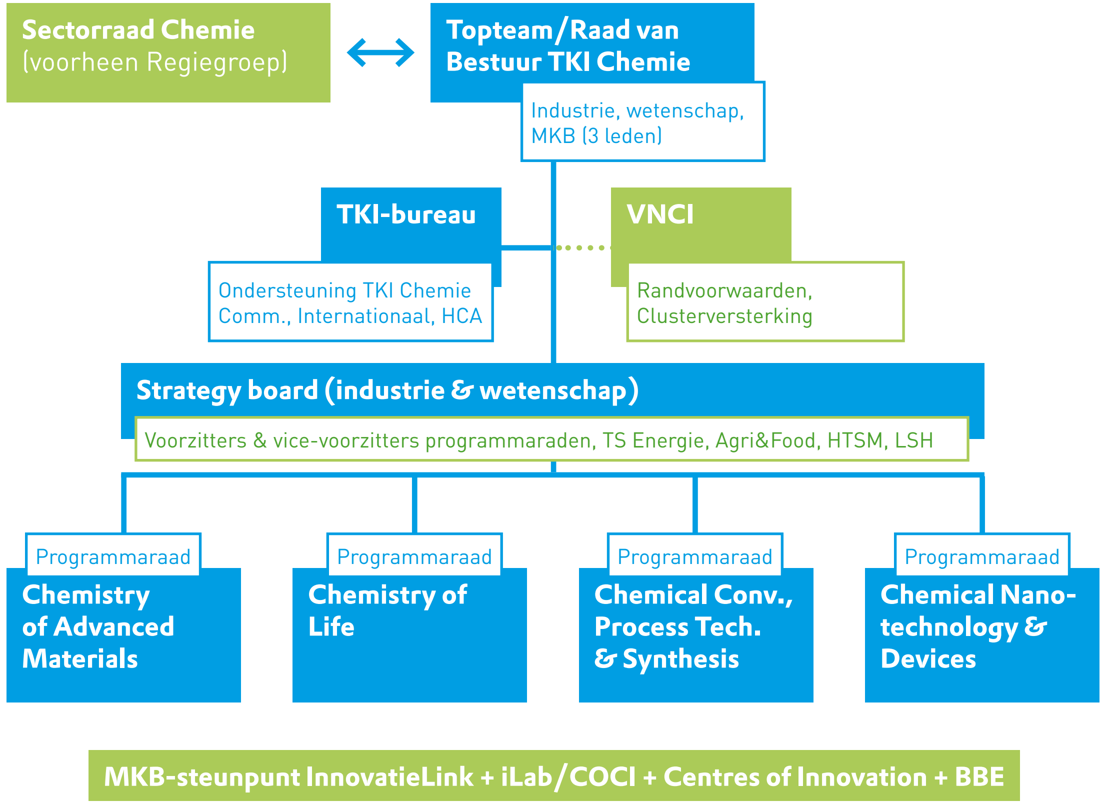
U
UbiQ Bio
Unilever R&D Vlaardingen
U-Protein Express

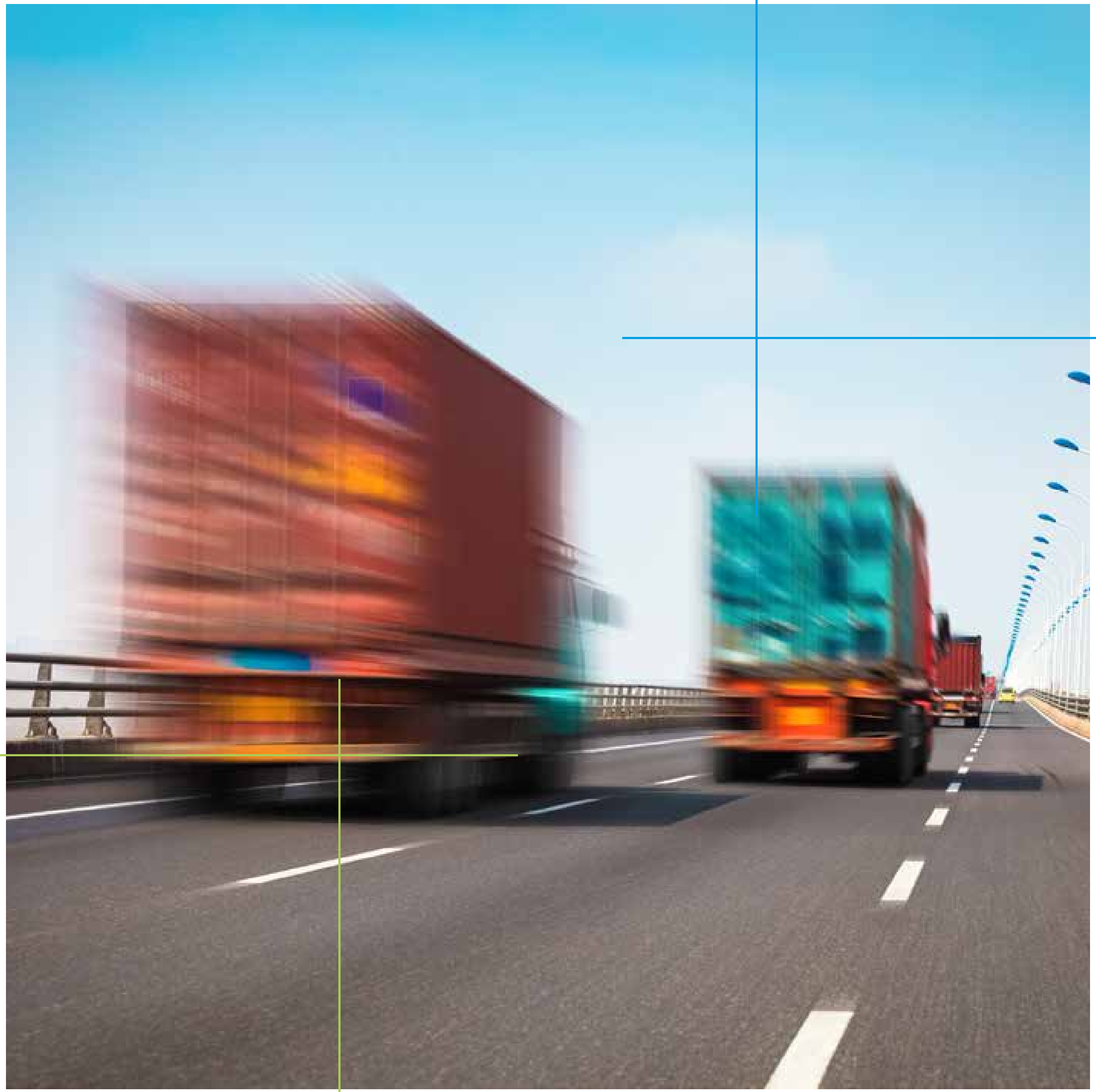
V
VDL
VibSpec-Training
Voltea

W
van Wijhe
Waters Chromatography

Z
Zeton
ZoBio

Appendix 3:
Organisatie Topsector Chemie







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