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Review article

Exploring Green Chemistry, Sustainable Chemistry and innovative business models such as Chemical Leasing in the context of international policy discussions



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ABSTRACT

This article provides an overview on Green Chemistry and Sustainable Chemistry in the context of the 2030 Agenda for Sustainable Development and different policy frameworks such as the EU Circular Economy Action Plan and SAICM, the Strategic Approach of International Chemicals Management. There is an increasing body of evidence suggesting the practicality and applicability of Green Chemistry and Sustainable Chemistry within industrial development policies and international agreements addressing chemicals and waste concerns. To explore the full potential of Green Chemistry and Sustainable Chemistry, the authors come to the conclusion that innovative business models are required to facilitate the engagement of the different players, including industry. While presenting the United Nations Industrial Development Organization (UNIDO)'s experiences and lessons learnt from ten years of work in UNIDO's Global Chemical Leasing Programme, the article also highlights the role that innovative and circular economy business models could play in achieving inclusive and sustainable economic growth. It therefore explores the potential of integrated Chemical Leasing, Green Chemistry and Sustainable Chemistry initiatives at the global level.

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1. Introduction

Chemicals are an integral part of daily life in today's world, and there is hardly any industry where chemicals are not used at all [1]. Chemicals and chemical products are one of the dominant global manufacturing industries, alongside the food and beverage sector, machinery and equipment [2]. Recent forecasts by the American Chemistry Council predict significant growth in chemical production in developing countries until 2021, compared to a more modest growth in developed countries (cited in Ref. [1], see Fig. 1).

Chemicals help millions of people all over the world to live a better and healthier life, to cure diseases and to protect the plants we need for food. However, they are also a possible source of risks to human health and safety and the environment, if not managed soundly.

2. Introduction to Green Chemistry and Sustainable Chemistry

Many concepts, theories and frameworks have been developed during the last decades in order to reduce and, where possible, eliminate the use of hazardous chemicals. Two of them are "Green Chemistry" and "Sustainable Chemistry". Green Chemistry was first defined by Anastas and Warner [3] as a framework "based on a set of 12 principles that when used in the design, development and implementation of chemical products and processes, enables scientists to protect and benefit the economy, people and the planet". The ultimate goal of Green Chemistry is to physically reduce the quantities of chemicals that have a negative impact on human health and the environment [4].

Sustainable Chemistry has been defined by the German Federal Environment Agency [5] as "the part of chemistry which is essential to a sustainable society with a view to product design, manufacturing, consumption of resources, health and safety at work, economic success and technical innovation – not only in industrialized nations but in emerging and developing countries too. Sustainable Chemistry thus extends far beyond the application

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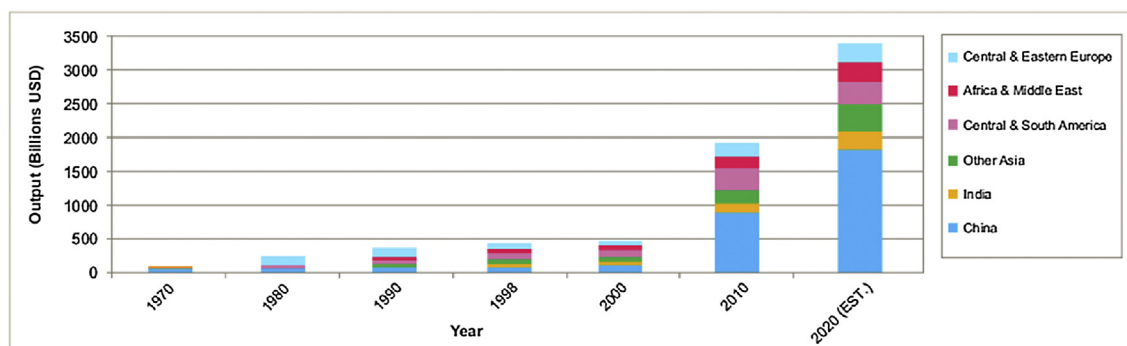


Fig. 1. Chemical Industry Output: Developing Regions (as categorized by UN Statistics Division) & Countries with Economies in Transition (Source: [1]).

of ecological principles in chemical production". It is assumed that the areas of Sustainable Chemistry and Green Chemistry will be further explored in an integrative way and exploited to new approaches such as innovative business models, ensuring the coherent and comprehensive development of research, policies and practical approaches.

2.1. Policy frameworks, mechanisms and initiatives

There are several existing policy frameworks, mechanisms and initiatives that can provide entry points to advance Green Chemistry and Sustainable Chemistry.

On 25 September 2015, the United Nations General Assembly adopted the 17 Sustainable Development Goals (SDGs) under the framework of the "2030 Agenda for Sustainable Development". The SDGs are a new, universal set of goals, targets and indicators that UN Member States are expected to use when framing their agendas and policies over the next 15 years. The United Nations Industrial Development Organization (UNIDO)'s mandate is to promote inclusive and sustainable industrial development to achieve shared prosperity and environmental sustainability and is particularly linked to SDG 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". However UNIDO strives to link its priorities with all the 17 SDGs, in order to ensure that, the Organization's programmes, projects and initiatives have positive synergetic effects in supporting the achievement of all the objectives of the 2030 Agenda for Sustainable Development [2].

The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) was established in 1995 to strengthen cooperation and increase coordination in the field of chemical safety and is the preeminent mechanism for initiating, facilitating and coordinating international action to achieve the "2020 goal", stating that chemicals shall be produced and used in ways that minimize significant adverse impacts on human health and the environment [6].¹

This "2020 goal" is also at the core of the Strategic Approach of International Chemicals Management (SAICM), adopted in 2006 by the International Conference on Chemicals Management (ICCM), which is a crucial international policy framework that aims to foster the sound management of chemicals (SMOC) in multi-stakeholder processes. The implementation of the Montreal Protocol, the Stockholm, Basel, Rotterdam and Minamata Conventions further contributes to the objectives of SAICM and relates to the importance of joint political action for prevention, reduction,

remediation, minimization and elimination of risks during the life cycle of chemicals. In this context, it can be noted that the United Nations Environment Assembly 2 (UNEA-2), held on May 23–27, 2016, in Nairobi, mentioned Sustainable Chemistry as an important building block of SMOC.²

On 2 December 2015, the European Commission adopted an ambitious Action Plan to stimulate Europe's transition towards a circular economy which aims to "boost global competitiveness, foster sustainable economic growth and generate new jobs" [7]. The circular economy approach is characterised by an economy that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times. It is conceived as a continuous positive development cycle that preserves and enhances natural capital, optimises resource yields, and minimizes system risks by managing finite stocks and renewable flows [8].

While it is notable that there are a number of legally binding and non-binding policy frameworks, mechanisms and initiatives related to chemicals, it is also evident that the impact of Green Chemistry and Sustainable Chemistry on them remains to be fully explored. Vice versa, smooth integration of Green Chemistry and Sustainable Chemical into industrial development policies may unlock the potential to achieve sustainable best practices across industries and countries.

2.2. The need for innovative and circular economy business models

Further awareness-raising and capacity-building on Green Chemistry principles and Sustainable Chemistry seems to be an important task for the future. Also, concrete examples of bridging the gap between science-based innovation and real-world application of Green Chemistry and Sustainable Chemistry need to be found, promoted and highlighted. One supportive feature could be the implementation of innovative and circular economy business models.

Since the Industrial Revolution, most economies have followed a linear model based on the assumption that "resources are abundant, available, easy to source and cheap to dispose of" [9]. In practice, many challenges have to be expected because of thermodynamics and not endlessly available resources. Circular economy systems, however, keep the added value in products for as long as possible. Waste is used as a resource in other parts of the value chain by shifting the focus to "closing the loop of product lifecycles through greater recycling and re-use" [9]. Transition to a more circular economy requires changes throughout value chains, from

¹ UNIDO is one of the Participating Organizations of the IOMC, together with FAO, ILO, UNDP, UNEP, UNITAR, WHO, World Bank and OECD.

² Note from the UNEA-2 outcome document available at <http://web.unep.org/unea/>.

product design to production processes to new business and market models. Applying innovative approaches is thus crucial for finding state-of-the-art solutions to use chemicals in ways to minimize their negative impact on health and environment and to enhance resource efficiency.

Traditional business models (“the more you sell the more you earn”) are fuelling the unnecessary consumption of chemicals and the generation of hazardous waste. The more chemicals are sold, the greater the economic benefit for the supplier, a dynamic which is often linked to an inefficient use of chemicals. Therefore, innovative business models are urgently needed, because they can contribute to the reduction of waste, chemicals consumption and use of resources and can minimize or even eliminate risk associated with inefficient chemicals management.

3. Chemical Leasing

Chemical Leasing is defined as a model where economic success no longer depends on the volume of chemicals sold but on the service that is linked with the chemicals. While shifting the focus from increasing the sales volume of chemicals to a value-added approach, the economic success of the supplier is shifted to the function and benefits of the chemical and no longer to the product turnover. Chemical consumption becomes a cost rather than a revenue factor for the supplier. Chemical Leasing contracts are typically centred on a functional unit of payment such as the number of pieces cleaned, the amount of area coated, etc.

By aligning business incentives, it is in the interest of the supplier and the user to optimize the use of the chemical in order to reduce the amount consumed, which consequently reduces costs, decreases risks related to chemicals management and minimizes the negative impact of chemicals on the environment (see Fig. 2). The new business model aims to bring economic advantages to all partners and provides concrete solutions for efficient chemicals management [10–12].

3.1. Potential of Chemical Leasing to contribute to the SDGs and to Green Chemistry and Sustainable Chemistry

In 2004, UNIDO, jointly with the Government of Austria, started a paradigm shift towards the resource-efficient and sound management of chemicals with the launch of the Global Chemical Leasing Programme. For more than ten years, UNIDO has been promoting the Chemical Leasing business model with partners from the private sector, as well as governmental and academic partners, and with a specific focus on developing and transition countries. It is noteworthy that the Programme received direct support from the Governments of Switzerland and Germany and is also closely connected to the joint Global UNIDO/UNEP Programme on Resource Efficiency and Cleaner Production (RECP) and the RECP network of National Cleaner Production Centres [13].

3.2. Practical implementation

By today, Chemical Leasing has been applied by companies in more than 14 countries in different sectors, ranging from metalworking to beverages and automotive production [11,12]. Many case studies have proven that Chemical Leasing combines the reduction in chemical consumption with economic benefits for all involved partners [14]. The concept encourages sound chemicals management based on long-term partnerships, fosters innovation and promotes sustainable production and consumption patterns. With the experiences gained over the years, an online-based Chemical Leasing Toolkit was developed to support technicians, businesspersons and policy-makers in the implementation and integration processes at different levels (<http://www.chemicalleasing-toolkit.org>). The Chemical Leasing Toolkit provides guidelines, materials, best practice case studies and lessons learnt from 10 years of work at UNIDO's Global Chemical Leasing Programme. The toolkit was developed to support the effective and efficient application of Chemical Leasing in practice and is designed as an interactive tool that aims to help industry and policy professionals to become more knowledgeable about the business model. The Chemical Leasing Toolkit, released in April 2016, is part of the recently updated web-based IOMC Toolbox. This Toolbox includes numerous chemical management tools available in IOMC Participating Organizations and is a problem-solving tool that enables countries to identify the most appropriate and efficient actions to address specific national problems related to sound chemicals management (available at <http://iomctoolbox.oecd.org/>).

A global study on Chemical Leasing within industrial and service sector cleaning operations showed that the business model could lead to considerable reductions in overall chemical usage within a specific application [15]. Positive results of pilot projects were also reported from Chemical Leasing arrangements in other sectors and industries, such as in the food processing sector or the hospitality industry [11,12,16]. In Serbia, for example, the introduction of Chemical Leasing in the packaging process at a confectionary company led to a decreased consumption of chemicals of 30%, reduced costs and improved working conditions. In a Brazilian case study, project partners agreed to implement Chemical Leasing in order to manage chemicals used in a five-star hotel. This resulted in a reduction of cleaning agents used by more than 40%, lowered water consumption, improved greywater re-use processes and elimination of packaging waste. It became clear that the concept of Chemical Leasing, by preventing waste, shifting to the use of non-hazardous substances, and introducing better chemicals management control processes, is fully congruent with the Twelve Principles of Green Chemistry as outlined by Anastas and Warner [3] and is aligned to the overarching approach of Sustainable Chemistry.

These are only two examples of how the implementation of Chemical Leasing in industries could bring significant benefits in all



Fig. 2. The Chemical Leasing approach in contrast to the traditional business approach.

three dimensions of sustainability (ecologic, economic and social) to the project partners [12,16]. By looking at the Global Chemical Leasing Programme's project database of more than 50 documented cases [11,12] it is evident that the further exploration of the inter-relationships and potentials of joint Chemical Leasing, Green Chemistry and Sustainable Chemistry initiatives could accelerate the spread of green and Sustainable Chemistry concepts not only to industrialized nations but also to developing countries and economies in transition.³ This becomes even more relevant in respect to the forecasts of global chemicals production and consumption shifts to the Global East and South [1].

4. Outlook and conclusions

It is foreseen that based on the implementation of the Post-2015 Programme Strategy [11], Chemical Leasing can encourage better cooperation among partners, stimulate innovation, and incentivize environmentally-benign chemicals management in the future. Chemical Leasing is an innovative and circular economy business model that can accelerate Green Chemistry and Sustainable Chemistry integration within international policy regimes and advance the integration of the three dimensions of sustainable development in chemicals businesses in pursuit of a circular and greener economy. By means of up-scaling and mainstreaming, sector-specific approaches, activities to achieve market change and enhanced policy integration, Chemical Leasing could eventually become a significant factor to foster the sorts of long-term, multi-stakeholder partnerships that are fundamental to the achievement of lasting change in the area of inclusive and sustainable industrial development.

With the adoption of the 2030 Agenda for Sustainable Development, and with regard to other on-going policy initiatives, there is a good momentum for bringing Green Chemistry and Sustainable Chemistry to the forefront of international policy discussions and debates. Developing countries and economies in transition are increasingly important to foster inclusive and sustainable industrial development, and green and Sustainable Chemistry concepts can have an important role in advancing this movement. This is the right moment for enhanced and integrative actions on Chemical Leasing, Green Chemistry and Sustainable Chemistry initiatives. Joint efforts at different levels are required to build the sustainable chemicals agenda that ultimately supports the creation of prosperity for people and planet.

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