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The academic journal for management issues in the chemical industry

Marios Hatzikyriakou

**Specialty chemicals and contending with forces of change**

Kai Pflug

**Impact of tightened environmental regulation on China's  
chemical industry**

Thorsten Bauer and Joachim Bohner

**The need for diversity in the chemical industry**

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# Contents

## Letter from the Editors

## Commentary

Specialty chemicals and contending with forces of change

Marios Hatzikyriakou.....94

## Practitioner's Section

Impact of tightened environmental regulation on China's chemical  
industry

Kai Pflug.....96

The need for diversity in the chemical industry

Thorsten Bauer and Joachim Bohner.....107

# Letter from the Editors

## Sensing and seizing opportunities

In order to be successful now and in the future, companies need to continuously sense their business environment in order to be able to seize emerging opportunities. The ability to identify and to invest in these upcoming chances will determine firm performance, in terms of growth, profits and competitive advantage. New business opportunities will likely arise when the industry's dominant logic is questioned. In response to these developments and to enable sustainable organizational growth, chemical companies are showing an increasing interest in start-ups and establishing strategic alliances beyond the traditional business sectors.

Transferring the idea of seizing opportunities to our journal, we are proud to announce that Dr Kai Pflug, will join our advisory board of the Journal of Business Chemistry. For the past 14 years Dr Kai Pflug has been residing in Shanghai where he has been conducting independent management consulting for the chemical industry. Being trained as a chemist and economist, he possesses the skills required to support the journal regarding management issues in the chemical industry.

In the commentary "Specialty chemicals and contending with forces of change" Marios Hatzikyriakou outlines the role of specialty chemicals and how they could be categorized according to customer needs and wants. Customer perception of uniqueness is based on a product's convenience, availability, functionality and the developed relationship between buyer and seller.

The article "The need for diversity in the chemical industry" written by Thorsten Bauer and Joachim Bohner addresses the important topic of diversity management in the chemical industry. Their results, drawn from an extensive survey, clearly indicate that diversity and inclusion are the most determining factors in corporate culture and management boards. Although it is difficult to find leaders who are able to manage this transformation process, the invested effort will pay off in the future.

Kai Pflug analyzes in his article "Impact of tightened environmental regulation on China's chemical industry" how the additional regulation and its stricter implementation will affect the chemical production in China. While the Chinese government intends to improve the environmental protection, these regulations will lead to a reduction of overcapacity, the closing down of small and uncompetitive companies, and higher entry barriers for other market participants.

Our current issue ends with the article "Managing business model innovation for relocalization in the process and manufacturing industry" from Ron Weerdmeester and Martin Geissdoerfer. The authors introduce the INSPIRE business modelling approach which helps managers in the process and manufacturing industry to develop innovative business models and makes them relocate value chain activities in Europe.

Please enjoy reading the third issue of the fifteenth volume of the Journal of Business Chemistry. We are grateful for the support of all authors and reviewers. If you have any comments or suggestions, please do not hesitate to contact us at [contact@businesschemistry.org](mailto:contact@businesschemistry.org).

Thomas Kopel  
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# Commentary

## Specialty chemicals and contending with forces of change

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Over the past decade, the chemical industry has experienced increased competition, declining margins, shorter product life cycles and subsequently a strong tendency towards product commoditization. In response to these challenging circumstances, chemical companies have adjusted their portfolios towards a higher degree of specialty chemicals.

Specialty chemicals and materials are products manufactured by the chemical industry that differ significantly from commodity chemicals and plastics. Distinguishing characteristics of specialty chemicals include quicker responsiveness to market and customer needs as well as higher required levels of technical service and application expertise. Customer perception of uniqueness places commodity chemicals and specialty chemicals at the extreme ends of a product continuum as illustrated in Figure 1.

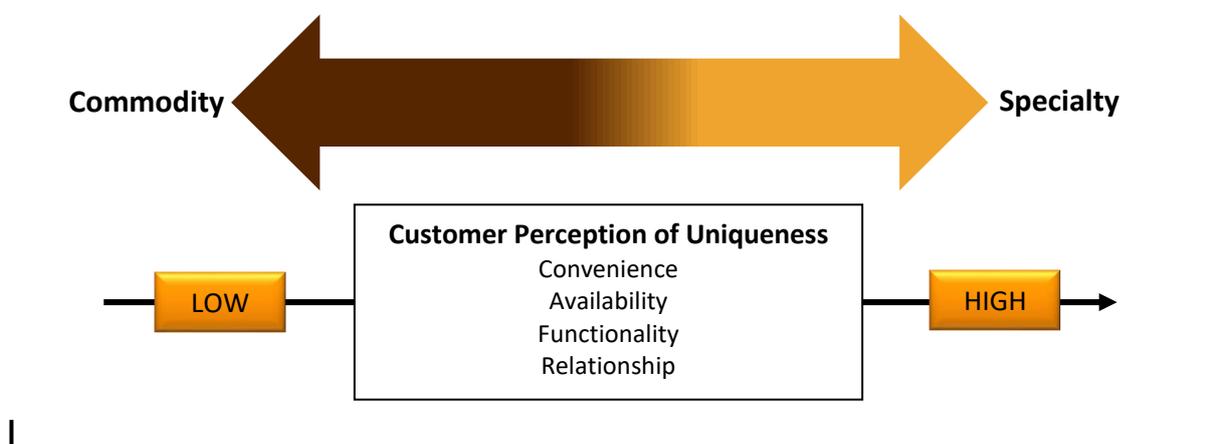
Commodity chemicals are sold on the basis of their chemical composition and specifications, which are generally without differentiation across many producers. Some commodity materials have high entry barriers due to:

- Scale of assets – giving low unit costs and/or requiring high capital investment
- Hazardous nature and/or onerous health, safety and environmental compliance requirements
- Requirements for grades with high purity and/or different product forms
- Logistics system constraints or costs

Alternatively, specialty chemicals generally utilize commodities as feedstocks, and are significantly smaller in scale of operation. Specialties exhibit a mixture of characteristics that distinguish them from commodities:

- Product characteristics and performance are differentiated from competitors, usually branded, and require technical support service
- Substitution is difficult, risky, or costly due to the performance of the material in customers' own products
- Value pricing, rather than cost plus pricing, results in selling prices that are less dependent on

Figure 1 The Commodity / Specialty Chemical Continuum (source: own representation).



industry utilization levels and fluctuating raw materials, utilities, or logistics costs

Specialty chemicals are categorized as either performance or fine chemicals. Performance chemicals are typically sold to customers on the basis of their functionality. Moreover, buyers expect suppliers to understand the functional systems with which their chemical products interact. Fine chemicals are typically the products of several stages of sophisticated chemical/biological synthesis, but are sold, like commodities, on the basis of chemical composition and specifications. Fine chemicals are often sold and used as intermediates to synthesize other chemicals. Further, fine chemicals are sold on the basis of composition because the buyer generally has sufficient knowledge about functional performance and does not require technical assistance from the supplier.

Customer perception of uniqueness is based on a product's convenience, availability, functionality, and the interrelationship developed between the buyer and the seller. Buyers will view their suppliers' base from different vantage points based on wants and needs, and thus will often determine what is a specialty and what is a commodity. Customers' wants and needs are highlighted in Figure 2 along with the type of specialty chemical required.

The specialty chemical industry has undergone many transformative changes over the past decade, including considerable realignment across the value and supply chains. Although the industry has mounted a concerted effort toward globalization, there has been significant consolidation evidenced by numerous mergers, acquisitions, divestitures, and joint ventures of companies varying in size and reach. In addition, external trends such as population, demographics, HSE (health, safety, and environmental) regulations, technological improvements,

changing life styles, and rising standards of living exert significant influences on the current and future demand for specialty chemicals.

Generally, specialty companies command higher valuations because specialty products realize higher margins due to differentiation, which comes at a significant price premium over commodities. However, specialty chemical company valuations are challenged by the following issues:

- Alignment of their client base with optimal levels of service and associated costs-to-serve
- Adjustments to existing supply chains and product distribution channels as well as development of new and viable channels
- Downward pressure on margins of mature, less specialized products, services, and systems as markets develop
- Alternative means for advertising, marketing, and selling such as through e-commerce
- Higher failure rate, and higher costs, associated with new product and business development
- Capture of increased value created from new product introductions
- Impact of scale on inherent competitive advantage
- Focus on higher shareholder value, with emphasis on increasing profitability and capital productivity

Therefore, specialty chemical companies that seek sustainable growth, improved profitability, and continuous operational improvement must address and incorporate strategies and tactics into their business plans to contend with these forces of change.

Figure 2 Customer Wants and Needs by Type of Specialty Chemical (source: own representation).



# Practitioner's Section

## Impact of tightened environmental regulation on China's chemical industry

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Environmental regulation of China's chemical industry has tightened considerably in the last few years, both with regard to the amount of regulation introduced and the severity of its implementation. This has had an effect on a number of aspects of the industry including the number of chemical producers, the location of chemical production, the prices of chemical products and the technology used for chemical production. The paper discusses these and other aspects as well as the impact on individual chemical companies and the underlying government objectives.

### 1 Introduction

Improving China's environmental situation is one of the key themes of Chinese president Xi Jinping. For example, at a study session attended by members of the Political Bureau of the CPC Central Committee in May 2017, Xi stated that the country should protect the environment "like one protects one's eyes" and treat the environment "as one treats one's life" [1]. This focus is likely to be the result of an increase in GDP per person accompanied by the adaption of middle-class interests and concerns, such as happened in Western countries a few decades earlier. Presumably strengthening environmental protection as a government objective is partly done to prevent dissatisfaction of the population, which could even lead to political movements similar to the "green" movement in the West.

The 13th Five-Year Plan covering the period of 2016-2020 was a particular turning point in increased environmental protection after some earlier attempts to focus on this topic, such as the introduction of a "Green GDP" figure, were not fully implemented due to the high revealed cost of environmental pollution in China [2]. The 13th Five-Year Plan includes green development as one of the five key development concepts for China [3]. Compared to previous plans, it increases the number of green

development quotas and enacts a stricter implementation process.

Indeed, additional regulation combined with stricter implementation has been the key feature of China's enhanced environmental protection in the past two years.

#### 1.1 Additional Regulation

Key regulatory changes within the last two years include a massive program of shifting chemical production to chemical parks, restrictions on the location of chemical production near the Yangtze river, the tightening of rules for many individual substances and substance classes and the introduction of an environmental tax, all overseen by a strengthened and renamed ministry.

The goal of shifting chemical production to chemical parks was first outlined in the 13<sup>th</sup> Five-Year Plan for the Chemical Industry (Petroleum and Chemical Industry of China, 2016), in which it is stated that during the period of the plan "the rate of new established chemical industrial enterprises entering the park will reach 100%, and the relocation of the enterprises outside the parks shall be accelerated". These high-level guidelines were later specified in more detail, providing a timeline for the different sizes of chemical companies. In addition, the

guidelines were transferred from a central level to the provincial level. For example, Fujian province in 2018 enacted the “Implementation Plan for the Relocation and Renovation of Dangerous Chemicals Production Enterprises in Urban Densely Populated Areas”, which states that small and medium-sized enterprises and large enterprises with major potential risks will start relocation and reconstruction before the end of 2018 and be completed before the end of 2020 while other large-scale and extra-large enterprises will start relocation and reconstruction before the end of 2020 and will be completed before the end of 2025. Other provinces including Anhui, Gansu, Guangdong, Heilongjiang, Henan, Jiangsu, Jilin, Shaanxi, Shanghai, Sichuan, Tianjin and Zhejiang have enacted similar guidelines. Some provinces even indicate target figures for the share of chemical enterprises to be located in chemical parks by 2025, aiming to reach 90% or higher from the current nationwide 45%.

At the same time, there is the objective of regulating or even reducing the number of chemical parks. The 13<sup>th</sup> Five-Year Plan for the Chemical Industry states that “in principle, no new chemical industrial parks will be established”. Indeed, some Chinese provinces have initiated the process to close or revoke chemical industrial parks (Dextra International, 2018), with some industry participants expecting the number of chemical parks to go down to about 480 by the end of 2018 from the 601 chemical parks existing at the end of 2017 (Cinn.com, 2018). However, given the fact that the number of chemical parks increased by almost 100 from the end of 2016 (502 parks) (Eastmoney.com, 2018) to the end of 2017 despite the objective of not increasing the number of chemical parks, this is a somewhat risky prediction.

Certainly, there are such developments on the level of individual provinces. Shandong province has announced the goal of halving the number of chemical parks in the province to 100 (ICIS, 2018). A first step towards this goal was the certification of 31 chemical parks as qualified. A second and third list of qualified chemical parks in Shandong are expected to be announced by the end of September and December (Liu, 2018). Shandong may serve as a model as it is reported to both have a low share of chemical companies located in chemical parks (37%) and a high share of GDP depending on the chemical industry (20%) (Liu, 2018).

In any case, the goal of controlling the number of chemical parks indicates that the objective of the relocation is not only to avoid chemical production being located close to population centers, but also to

allow for a better control of the individual chemical companies therein, in particular with regard to their environmental efforts.

Even within some chemical parks, limitations have been imposed with regard to the location of chemical production, particularly in the Yangtze area. Chemical industry projects have been prohibited within one kilometer of the Yangtze and its major tributaries (International Rivers, 2018), a regulation that also applies within chemical parks near the river.

Apart from regulating the location of chemical production, the regulation of emissions and of energy consumption has also tightened considerably. For example, the Ministry of Environmental Protection has published Emission Standards of Pollutants for Calcium Carbide Industry, which came into effect on July 1st, 2018. When discharging air and water pollutants, existing and new producers are to comply with these standards, which are the first to specifically apply to calcium carbide (China Chemical Reporter, 2018b).

Similarly, regulations are enacted further downstream, often on a provincial level. For example, from the beginning of 2019, the use of water-based coatings will be mandatory for motor vehicle maintenance companies operating in Tianjin. In July 2018, Hebei province implemented new emission limits on water pollutants. These limits are expected to reduce chemical oxygen demand by 32.9% and ammonia nitrogen emissions by over 58% from the 840 chemical firms in the province (ICIS, 2018).

Such provincial-level measures also indicate that the provincial governments now seem to compete with each other based on their environmental credentials (China Chemical Reporter, 2018b). The government will also check if key firms in high energy-consuming industries – including more than 2000 chemical and petrochemical companies – have reached the mandatory energy consuming standards, and sanction those companies not following the regulation (China Chemical Reporter, 2018c).

Taxation is employed as another tool to improve environmental protection. In 2018, an environment tax was introduced. Under this regulation, pollution of soil and air are taxed under a uniform set of national rules instead of the previous system of pollution fees on a local level. As the new tax is imposed by the central government and not as previously by local governments, it is easier to implement and not likely to be easily waived for political or economic considerations. The environment tax varies by pollution type, location and severity and covers both air

pollution and noise pollution. An official study expects revenue from this new tax to at least double compared to the previous pollution fee system (South China Morning Post, 2017). The new system also provides incentives for polluters to reduce emissions, as the tax on emitters is reduced if their emission volumes are substantially lower than the permitted limits.

Finally, the intensified efforts to mandate environmental protection in China are also reflected by changes in the responsible government organs. Specifically, in March 2018 new China Ministry of Ecological Environment replaced the previous Ministry of Environmental Protection, which itself had only been promoted to the rank of a ministry in 2008. The new ministry has added responsibilities for climate change, agricultural pollution, marine ecology and related issues, which were previously scattered across various government organizations. The increased responsibilities of the ministry highlight the growing importance of environmental protection in China and should simplify the focus on these efforts by putting them under a unified control.

### 1.2 Stricter Implementation

In the past, improving the environmental situation in China often faced huge obstacles as implementation of environmental regulation proved to be difficult on a local level, partly as local government officials were primarily incentivized on the basis of economic growth and thus tended to overlook environmental violations that were felt to facilitate faster growth. However, in July 2016 a nationwide campaign of environmental inspections was started, focusing on a few selected provinces at any given time. These inspections are far stricter than in the past as they are unannounced and often followed by fines and/or temporary production stops. These strict inspections are likely to be the key difference to previous environmental efforts as for the first time, regulations are actually implemented without major exceptions. The anti-corruption campaign started by Xi Jinping supports these environmental efforts as the evasion of regulation via bribery and/or local connections has become much more difficult. In addition, about 15,000 government officials so far have received punishments after the inspections. As a consequence, some observers in Western chemical companies now report that close relationships to local authorities are no longer vital as government authorities follow a strictly rule-based approach. Another round of inspections has started on June 11,

2018 and will continue until April 28, 2019, covering many of the most important chemical production areas in China (Xu, Stanway, 2018). The resources to execute these inspections were increased to two hundred teams with a total of about 18,000 inspectors and support staff, showing the determination of the central government to insist on strict implementation of the regulation.

The stricter implementation will also cover waste disposal by chemical companies. The government has launched nationwide inspections covering the transfer and disposal of waste, and companies not able to meet the standards for waste disposal will not be allowed to move into chemical parks, which in itself is a precondition for being allowed to continue production in the longer term. After some initial failed inspections, mayors of seven Chinese cities were ordered by the ministry to improve their system of disposing chemical and other hazardous waste (Xu and Mason, 2017).

## 2 Impact on China's chemical industry: Factors

We will now examine the impact the above tightened environmental regulation has had on the chemical industry primarily in China, but also overseas.

Key aspects include factory closures, factory relocations, plant modifications, capacity reductions/reduced operating rates, technology changes, higher prices, shift from export to import, changes in approval practice for new chemical plants, impact on foreign competitors, changes in industry structure, changes in mindset, and opportunities for Western companies.

Due to the large number of chemical companies in China, the rapidly changing landscape and the limited information available on some companies, these aspects cannot be covered comprehensively but will instead be highlighted via individual examples.

### 2.1 Factory Closures

Closures of chemical plants are the most visible indication of China's tightened environmental regulation. They arguably have the largest impact on the chemical industry as the capacity of the plants closed is eliminated from the industry.

Examples include the following.

**Anhui province** will close six chemical plants (Suratman, 2018).

In **Heilongjiang province**, 14 chemical plants will be closed down (Zhang, 2018).

**Jiangsu province** plans to close 2077 chemical plants in 2018. The province was under intense scrutiny in a round of inspections in April/May 2018, during which a number of listed chemical companies including Nanjing Chemical Fibre, Lianhe Chemical Technology, Jiangsu Yabang Dyestuff and Jiangsu Yoke Technology were found to violate environmental protection regulation (Suratman, 2018; Zhang, 2018). In one specific city, **Changzhou**, 40 chemical plants were closed within the first few months of 2018.

**Shandong province** is targeting to close 20% of the 4930 chemical plants located in the province (Suratman, 2018).

**Sichuan province** plans to close nine chemical firms (Xinhua, 2018).

**Yichang city in Hubei province** has closed down 25 chemical plants since 2017 (Xinhua, 2018). The plants closed down come from different chemical segments. Many of them are producers of basic chemicals while others are mainly involved in downstream activities such as formulating chemical products (e.g., paints). High-end chemical companies seem to have been largely spared so far. In fact, information from a number of Chinese industry participants and observers points to the fact that many of

the companies closed down do not only contribute substantially to environmental pollution but also suffer from economic problems such as low profitability, low capacity utilization and low quality of the products produced.

According to the China Petroleum and Chemical Industry Foundation (CPCIF), the number of chemical and petrochemical companies in China with annual revenues above 20 million RMB decreased by 1666 from 29307 companies to 27641 companies (-5.7%) from the end of June 2017 to the end of June 2018 (China Chemical Reporter, 2018f). Most of the closures were for chemical companies (-1565) rather than for refining or oil and gas companies. During this period, the revenue of the chemical industry increased by 12.4%, the profit rate increased from 6.1% to 7.1% and average capacity utilization for a basket of 28 chemicals increased by about 3% to 72%. While there are other possible reasons for these company closures, it is likely that the tightened environmental regulation played a major role, particularly as these closures happened during a period of increasing profit, sales and capacity utilization.

So far, the coastal provinces of Shandong and Jiangsu have announced the most wide-ranging plans for factory closures (see Fig. 1). In addition, due to its close proximity to the Beijing/Tianjin cluster, Hebei province is also likely to close a substantial number of chemical factories. In addition, it is very likely that other provinces – first those on the Chinese seaboard, but later also inland provinces – will increasingly be affected.

Figure 1 Provincial map of China with provinces particularly affected by closures of chemical companies (source: own representation).



## 2.2 Factory Relocations

While not as harsh as closing down a factory, the requirement for relocation into a chemical park also has substantial consequences for those chemical plants affected. These include the need to identify and secure space in an approved location such as a chemical park, the shift of existing production equipment to the new site or the investment in new equipment, and frequently the acceptance of tighter emission regulation at the new site, which may require further investment in emission control. Apart from the direct costs of such a relocation, indirect costs include the possible interruption of production if the equipment is relocated, the time needed to secure a smooth production process at the new site, and the potential loss of qualified workers not willing to work at the new site. Depending on the local importance of the chemical plant affected, local government may financially support the relocation.

Several provinces have indicated numbers of chemical plants to be relocated. Typically, these numbers are larger than the number of plants being closed. Examples are given below.

In **Anhui province**, 34 chemical plants are to be moved into chemical parks (Suratman, 2018).

**Heilongjiang province** will relocate 5 chemical plants (Zhang, 2018).

**Sichuan province** will relocate 37 chemical plants (Suratman, 2018).

A number of **producers of sulfuric acid** will relocate their production. Companies include Hubei Zhongfu Chemical Industry Group Co., Ltd., Yichang Xinyangfeng Fertilizer Co., Ltd., Xiamen Xiahua Industrial Co., Ltd. and SinoChem Fuling Chemical Industry Co., Ltd. The total capacity to be relocated will be over 8.00 million t/a. (China Chemical Reporter, 2018d)

Relocation may not be straightforward for all chemical companies. At least in the Eastern provinces, chemical parks are becoming increasingly restrictive with regard to the companies being allowed entry, with refusal rates of 60-70% not uncommon. Criteria applied include the environmental pollution of the chemical plant as well as the investment planned in the chemical park, effectively creating additional entry barriers for smaller chemical companies, particularly in highly polluting chemical segments. For example, the government of Shandong province will limit the approval of the production of hazardous chemicals to projects with an investment of at least 300 million RMB (about 40 million Euro) (China Chemical Reporter 2017).

Some relocation may be done proactively, particularly if it is combined with a capacity expansion which would not likely have gotten approval at the historical site. For example, in July 2018 AkzoNobel Specialty Chemicals broke ground on a new organic peroxide production facility in Tianjin, China. It will be located in the Tianjin Nangang Industrial Zone. According to the Akzo Nobel press release, the new plant "supports efforts being made by Chinese authorities to optimize urban planning and produce an industrial upgrade in the country's chemical industry" (Akzo Nobel, 2018). This presumably refers to the government relocation plan for the chemical industry in China.

## 2.3 Plant modifications

The typical outcome of plant inspections is not a shutdown or a forced relocation, but rather a request for a modification of existing processes in order to lower emissions. Frequently these require shorter production stops (e.g., a few weeks) and some investment in emission control. For example, while Heilongjiang shut down 14 chemical plants and required relocation of 5 plants, a total of 69 plants were requested to modify and upgrade their processes (Zhang, 2018b). Typically, such modifications do not result in a longer-term capacity reduction, but they may increase production costs.

## 2.4 Capacity reductions / reduced operating rates

Frequently companies had to reduce their operating rate and thus their overall capacity as a result of government restrictions on emissions. An affected segment is Chinese caustic soda production. In this segment, environmental inspections were reported to lower operating rates to around 70%, and sometimes even to 50% (Han, 2018).

While China theoretically has an overcapacity of maleic anhydride, restrictions on emissions led to shortages in production as the theoretical capacity was only utilized at 50-60%. This resulted in shortages of the chemical in Europe, which depends on imports from China (Beacham, 2018).

**Table 1** Examples for shift towards more environmentally friendly production technologies for chemicals in China as a consequence of tightened environmental regulation (source: own representation).

Product	Preferred production technology (more environmentally friendly)	Less preferred production technology (less environmentally friendly)
Methanol	From natural gas	From coal
PVC	Ethylene-based	Carbide based
Sulfuric acid	Smelting-based	Pyrite-based
Titanium dioxide	Chlorination process	Sulfuric acid process

## 2.5 Technology changes

There are several important chemicals which can be produced by more than one economically viable route. In fact, the use of coal as a raw material replacing naphtha is one of the key characteristics of the chemical industry in China as compared to the industry in the Western world, owing to the relative lack of oil resources and the relative abundance of coal in China.

The different production routes typically do not have the same impact on the environment. As a consequence, the tightening of environmental regulations in China will lead to a shift towards the more environmentally friendly technology. Frequently this is the technology that is already being favored in the Western world. The table below gives some examples for such a technology shift as a consequence of tightened environmental regulation in China. The shift may either happen by closing down plants based on the less preferred technology, or by only approving the preferred technology for new plants, or by a combination of both.

A similar shift also occurs on the level of product technology. For example, government policy favors water-based coatings over solvent-based coatings, and the target for 2020 (as stated in the 13th 5-Year Plan) is to reach a 57% market share of water-based coatings from the 46% share it had in 2016.

## 2.6 Higher Prices

Predictably, the capacity closures and restrictions on operating rates have caused prices for some affected chemicals to rise substantially. Dyestuff prices in China rose substantially in 2017. For disperse dyestuffs the 2017 price increases were as high as 25%-37%. Dyes are a segment particularly affected by the tightening of environmental regulation, as traditional dyestuff production creates

large amount of waste water. As a consequence, a number of companies had to shut down, leading to the price increases observed (China Chemical Reporter, 2018e).

Similarly, the spread between the raw material toluene and toluene di-isocyanate was close to the highest spread since 2000. This was reportedly a consequence of the 2017 winter air campaign, which caused a tightness for natural gas as the use of coal was limited in order to improve air quality. Subsequently, local authorities halted supply of natural gas to PU manufacturers (Richardson, 2018).

Caustic soda is also among the chemicals affected by increased environmental regulations in China, with prices having almost doubled between 2016 and 2017 (Han, 2018).

## 2.7 Shift from import to export

An interesting effect of the reduced production of some chemicals as the consequence of increased environmental regulation is that China in some cases has turned from an exporter to an importer. For example, China has been reported to import dye raw materials such as vinyl sulfone and H-Acid (1-amino-8-hydroxynaphthalene-3,6- disulfonic acid), an important dye intermediate) from India, reversing its previous role as an exporter to India, as local production of these chemicals declined by 50-60% (Times, 2018). As a consequence, prices in India increased by about 30%.

## 2.8 Changes in approval practice for new chemical plants

Several managers of chemical factories (both foreign and domestic) have mentioned longer approval times for new chemical plants as the local authorities are more careful in scrutinizing such plants. In one

example, the stated approval time changed from 6 months to 18 months.

### 2.9 Impact on foreign competitors

While the tightened environmental regulation in China may have a negative effect on companies sourcing chemicals from China, it also has some benefits for foreign firms in competition with Chinese chemical producers. For example, several Japanese chemical companies benefit from reduced competition from China as a consequence of tightened environmental regulation. Showa Denko expects its operating profit to jump 80% on the year in fiscal 2018 as they profit from price rises for graphite electrodes, demand for which has been driven by China switching to cleaner steel production. Similarly, Japanese PVC producers such as Tosoh and Asahi benefit from China's crackdown on coal-based PVC (Nitta, Suzuki, 2018). Indian producers of dye intermediates also profit from the reduced Chinese capacity, which has allowed them to substantially increase prices (Moneycontrol, 2016).

### 2.10 Changes in Industry structure

The tightening of environmental regulation frequently results in some consolidation within chemical segments as small plants are more likely to be closed down and tend to have less investment capital required to upgrade production processes or to move to chemical parks.

For example, for sulfuric acid, the output of the top 10 Chinese producers rose to 37.5% of the total production in 2017 from 35.6% in 2016 (China Chemical Reporter, 2018d), though the tightened environmental regulation may not be the only reason for this shift of market share.

In a market survey conducted by consulting company Management Consulting – Chemicals, 10 producers of specialty toluene derivatives were examined. It was found that of 10 producers active in 2016, only 4 (40%) were still producing in June 2018. Even these companies reported some short-term production stops in the past. Interestingly, none of these four companies has immediate plans to increase production capacity as they are all located in relatively low-level chemical production zones and thus fear they may be affected by a further tightening of regulation (Management Consulting, 2018).

### 2.11 Changes in Mindset

The focus on environmental protection has also already led to a partial change in mindset among local government and particularly those responsible for supervising chemical plants. There are reports of scared government officials indiscriminately closing down chemical production in individual locations after a single company has violated environmental regulation. On the other hand, when the author in February 2018 attended a showcase presentation of the Changzhou National High-Tech District, he was surprised to hear that the presentation boasted of shutting down 35 chemical companies. It is certainly a sign of the changing attitude towards environmental pollution that such a statement is now used to highlight the qualities of this industrial zone, rather than to show its restrictions.

### 2.12 Opportunities for Western companies

Some Western chemical companies may benefit from the tightened environmental regulation. This applies to multinational players producing chemicals overseas that compete with chemicals produced in China, which may become more expensive or suffer from capacity reductions. Even when producing within China, Western companies may benefit from tighter regulation as due to their global processes, their environmental standards are typically already higher than those of local players, resulting in fewer interruptions and cost increases.

In markets targeted both by Western and by Chinese chemical producers, Western players may also benefit from a decrease in competition from Chinese competitors as these may be affected by cost increases, capacity reductions and production stops. Another opportunity for dedicated companies is to sell high-value production know-how and pollution control equipment to chemical plants required to upgrade their processes.

Finally, relocation will often require investment in new equipment rather than the reusal of existing equipment. Due to the increased standards, it is more likely that foreign engineering companies get a share of this business.

## 3 Impact on China's chemical industry: Individual companies

Not all chemical producers in China will be affected by the tightened regulation to the same

extent. The table below gives an indication of which parameters determine the impact of the regulation on individual companies.

#### 4 Government objectives

One obvious objective of the tightening of environmental regulation is to improve environmental protection. Closely related is the target of ensuring safe chemical production.

However, several government documents such as the one issued by Fujian province on relocation of chemical companies also hint at an additional objective, the improvement of the industry structure (Fujian Province, 2018): “For those industries with **weak market competitiveness and small scale**, where

there are potential safety hazards in the production and transportation process and do not conform to the direction of industrial development, **they should close down and relocate, and do not implement relocation in other places**; and those with serious safety risks should be closed as soon as possible. For industries with excess capacity, **equal or reduced relocations** must be implemented, and **no opportunity should be taken to expand production capacity.**”

In personal communications with the author, a number of Chinese industry participants stated that indeed the closing down of small and uncompetitive chemical companies and the resulting improvement of margins and reduction of overcapacity are indeed a major objective of the tightened government regulation. Such measures are implemented in a much

**Table 2** Factors determining the impact of tightened environmental regulation on individual chemical producers in China (source: own representation).

Factor	Influence	Rationale
Capacity utilization	Companies in segments with overcapacity will be more affected	Among the goals of the tightened regulation is to reduce overcapacity
Chemical segment	Companies in low-end and highly polluting segments will be more affected	Among the goals of the regulation is to raise the quality of the chemical industry (Petroleum and Chemical Industry of China, 2016)
Company size	Bigger companies will be less affected	Larger companies will be given more time to relocate, and get more government support
Emissions	More polluting companies will be more affected	Higher costs to meet the tightened emission requirements
Industry structure	Companies in fragmented industries will be more affected	Among the goals of the tightened regulation is to improve industry structure and to consolidate industry segments
Location	Companies in highly developed Eastern provinces will be held to higher standards	Provinces are allowed to set standards that are higher than those set by the central government. This will primarily be employed by wealthier provinces with alternatives to chemical production
Profitability	Unprofitable companies will be more affected	These companies will have less incentive to invest in upgrade and relocation
Production technology level	Older technology will be more affected	Older technology is typically more polluting

more direct way in areas such as steel and coal, e.g., via reducing the number of workdays at coal mines or closing down older and inefficient steel plants (Xu and Daly, 2018). In chemicals, such an approach may be less workable due to the large number of different chemical segments and products, which would make it extremely difficult to set suitable targets for the right type and number of chemicals.

However, on the level of individual provinces, some targets are being set with regard to the reduction of the number of chemical companies. Examples for such targets include Jiangsu province and Shandong province (Suratam, 2018). But overall, the central government seems to be confident that increasing the entry barriers and investment requirements for chemical companies (via, e.g., requiring more expensive emission prevention equipment and relocation to chemical parks) will on its own already reduce the number of market participants and reduce capacity, which is generally acknowledged to be excessive for many chemicals.

## 5 Outlook and Conclusion

There is a general perception among industry participants that the current environmental drive will continue for at least the next few years. Chemical companies cannot expect the current environment of tightened regulations to change. In fact, the relocation plan covers the period to 2025, and it would be a substantial loss of face for the Chinese government to backtrack.

On the other hand, the chemical industry in China is still growing. Revenues of the Chinese chemical and petrochemical industry grew by 12.4% in Jan-Apr 2018 compared to the same period in 2017 (China Chemical Reporter, 2018f). And while obviously not directly comparable with the situation in China, it is worth remembering that as much as REACH was objected to during its introduction in Europe, it is now widely seen as giving Europe's chemical industry a competitive advantage (C&EN, 2018).

It is therefore not justified for chemical companies to decrease their focus on China. In fact, industry organizations such as CEFIC predict that China's share of the global chemical market will increase further, from 40% in 2016 to 44% in 2030 (CEFIC, 2017).

In fact, the current changes of the Chinese chemical industry from a focus on production volume independent of quality level and environmental consequences to a more balanced model may offer substantial opportunities to those chemical companies

that already had to make this switch a few decades earlier. The higher environmental requirements may give Western chemical companies the kind of competitive advantage which – given their decline in their share in China's chemical market in the past decade – they were increasingly losing.

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# Practitioner's Section

## The need for diversity in the chemical industry

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The signs are clear, the focus on Diversity & Inclusion (D&I) in business is by no stretch of the imagination just a fad. It will therefore also remain an important issue for chemical industry companies in years to come.

An extensive survey of Russell Reynolds Associates has discovered that D&I is the most determining factor of corporate culture in management. Management boards are dragging behind but achieving clear progress in the field of diversity management. What is needed now is a clear view on what kind of behavior leadership needs to exhibit to bridge the gap between observed and desired levels of diversity and inclusion. It is key to identify those managers that enable the cultural transformation in a sustainable way.

### 1 The importance of diversity management

The term *diversity management* can look back on an impressive career. It started out as a US civil and political grassroots movement in the 1960s, an amalgamation of the women's rights and civil liberties movements. In the past decade, however, diversity management increasingly became a business management concept, seeking to recognize diversity and utilize it for the benefit of all concerned.

Specifically, diversity aims to recognize people's varied achievements and experiences and to grasp and utilize their potential. Eliminating discrimination and promoting equal opportunities are the core objectives. Fundamental aspects representing human diversity are mostly held to be age, gender, ethnicity, social background, sexual orientation, and physical and psychological condition.

As a consequence, the turnaround in recent years regarding attempts to increase the number of female executives in businesses happened not only as a result of moral scruples: many companies realized the

need for greater diversity among their leadership and workforce to guarantee their place at the top. This push for greater diversity is not only of benefit to management, by way of increased profits and employer branding, but also to employees. For example, current research supports the assertion that growth in the number of female leaders has a distinct impact on company culture and talent decisions. Talented individuals that may otherwise be overlooked have a higher chance of being developed and promoted, leadership assessments are conducted in a more objective manner, and knowledge is built across the organization through mentoring programs (Byham, 2018).

The higher the corporate level, the greater the impact of diversity is. Continuing the example of gender diversity, this year's McKinsey Report restates that companies with greater gender diversity can hope to achieve greater profits. According to Hunt et al. (2018) companies on the lower rungs of the diversity ladder can expect sub-par results.

Moreover, companies employing a greater number of women in leadership positions are mentioned in the same breath with supreme financial performance or greater across-the-board success. When it comes to the prevailing view in the public opinion, diversity affords individuals, teams and organizations an advantage. The following advantages are often mentioned in the public debate:

- better initiation of business contacts, resulting in advantages on international markets;
- improved employer branding, following from possibilities of hiring top international talents;
- generating a better image towards clients and enhancing responsiveness to a variety of customer demands;
- better prerequisites for innovation, lower organizational blindness;
- performance enhancement through more effective teamwork, lowered chance of groupthink in teams;
- higher motivation because of higher identification of employees with their companies.

## 2 Diversity management in the chemical industry in the USA, Europe, and Asia

What then is the current situation in the chemical industry? In its September 2017 issue, *Chemical & Engineering News* (C&EN), published by the

American Chemical Society, printed survey results showing that women then occupied 16.7% of 430 board director seats at 43 US chemical companies (Tullo, 2017). That was an increase of some 16% compared to the previous year.

In Europe, the female top leadership share is even higher with the trend continuing upward. C&EN's 2017 survey found that in 13 chemical companies examined, more than every fourth board seat, namely 28.6 % of 154 such seats, was filled by a woman (Tullo, 2017).

C&EN said that Europe's trailblazers, as depicted in table 1, included Air Liquide, whose supervisory board had 5 female and 7 male members. Akzo Nobel had 3 women and 5 men on their supervisory board, as did Syngenta and Yara. DSM's supervisory board was on its way to achieving a similar setting with 3 women currently facing 4 men.

C&EN discerned an upward trend at Bayer, BASF, Evonik, LANXESS, and Solvay, but women still are a distinct minority on the supervisory boards of these companies.

Efforts to achieve greater diversity on management boards have not been as pronounced, says C&EN. The gender ratio on management boards at Europe's chemical giants is 7:1, i.e. seven males to one female in management - a significant difference when compared to supervisory boards, where the average ratio is 2:1 in favor of men (see table 1).

But management boards can also be proof of

**Table 1 Women at European Firms (Source: Tullo, 2017).**

Company	Supervisory Board		Management Board	
	Total	Women	Total	Women
Air Liquide	12	5	12	1
AkzoNobel	8	3	7	1
Arkema	13	5	8	1
BASF	12	3	8	1
Bayer	22	5	7	1
DSM	7	3	4	1
Evonik Industries	20	7	5	1
Johnson Matthey	6	2	3	1
Lanxess	12	2	4	0
Linde	12	3	4	0
Solvay	15	5	5	0
Syngenta	8	3	7	1
Yara	8	3	12	3
<b>TOTAL</b>	<b>155</b>	<b>49</b>	<b>86</b>	<b>11</b>

diversity accomplishments, as shown by the Dow Chemical Company. Dow's 2017 annual report revealed that their executive leadership council consisted of 10 men and 5 women – the share of women was thus a third.

Some Scandinavian companies, especially Norwegian firms, have an even greater proportion of women. This could be the result of drastic regulation; even in 2004, the Norwegian governmental board gender quotas that forced all public enterprises to achieve a quota for both genders of at least 40% for all new hires. In 2006, this rule was also applied to the publicly listed companies, who were granted a 2-year transitional period. As of 2017, the share of female executives in publicly listed companies has raised as high as 42.1%. The respective share of women in leadership positions across all not-listed commercial companies is “only” 18.4%, based on Statistics Norway (SSB).

A survey on Women in Business and Management: Gaining Momentum, published by the International Labour Organization, found that Norway's 13.3% pertaining to companies with a woman in a board seat was the highest percentage worldwide. Norway's total number of women on boards exceeds 20%, which puts it at the top of the table together with Finland, Sweden, and the UK. At the other end, with only around 5% of women in leadership, Russia, Saudi Arabia, Chile and Japan are to be found.

Without a doubt, Norway is a diversity trailblazer, not only in Europe and in the chemical industry, but indeed globally, especially because of its comparatively stringent legal measures.

The large proportion of women in leadership in Norway is also the result of female shareholder elected board members assuming multiple board seats. To meet legal requirements, women in Norway tend to fill far more than the three board seats considered feasible for anybody holding down an operational job as manager or C-suite executive. This development, caused by the severe government-mandated regulation, is now seen very critically in Norway, too.

Looking at the German chemical industry, the BASF board consists of 6 men and 1 woman. In 2010, the board contained only men. The world's largest chemical concern's annual report contains this statement: "BASF views the development and advancement of women as a global duty – independent of individual group companies. To achieve this, we have set ourselves ambitious global goals and made further progress in 2017. BASF will keep working on increasing the share of women in the leadership team. To this end, the company is applying measures across the world and continually working on evolving them."

Nonetheless, the road to gender equality seems to be a long one, not only at BASF, but at all German chemical companies. This opinion is expressed by the Verband Angestellter Akademiker und leitender Angestellter der Chemischen Industrie (VAA). The most recent survey in 2015 of 2,000 executives showed that women were represented in leadership positions much less frequently than men, even if they had the same qualifications and the same age (VAA, 2015).

**Table 2 Percentage of board seats held by woman (source: Catalyst Inc. Knowledge Center, 2014).**

> 20%	10 - 20 %	5 – 10 %	< 5 %
Finland	Australia	Belgium	Bahrain
Norway	Austria	Brazil	Chile
Sweden	Canada	China	India
United Kingdom	Denmark	Greece	Japan
	France	HK China	Kuwait
	Germany	Indonesia	Oman
	Israel	Ireland	Portugal
	Netherlands	Italy	Qatar
	Poland	Malaysia	Rep. of Korea
	South Africa	Mexico	Russia
	Turkey	New Zealand	Saudi Arabia
	Switzerland	Singapore	Taiwan
	USA	Spain	UAE
		Thailand	

Despite similar ages and qualifications, the VAA criticizes that only 26% of women interviewed were executives in their companies while that figure for men stood at 36%. Gender inequality was particularly significant in higher positions like departmental heads, managing director's (MDs), or board members. Only 4% of women had such jobs, while the number for men was more than double that at 9%. The survey also examined and checked variables like age, education, time at the firm, and job content specifics.

The professional portal *produktion.de* provided the information that in 2015 only three of the leading German chemical companies achieved the 30% women quota, which was written into law the next year. The research institute Statista looked at the number of women on supervisory boards in the chemical industry in 2015 and found that none of the top ten achieved parity, but all had at least 25% of women serving as supervisory board members.

There is not much solid information on the diversity situation at Asian companies at present. In April 2018, McKinsey's Global Institute criticized that across all industries, even in the developed Asia-Pacific economies, not many women managed to advance into companies' top echelons. In Japan, said McKinsey, there were no female CEOs "in the top 100 public companies". In Australia and Singapore, female CEOs made up 6% and 5%, respectively, in 2016. The Philippines –traditionally a matriarchal society – also only achieved a 3%-share in female CEOs and 15% in board members.

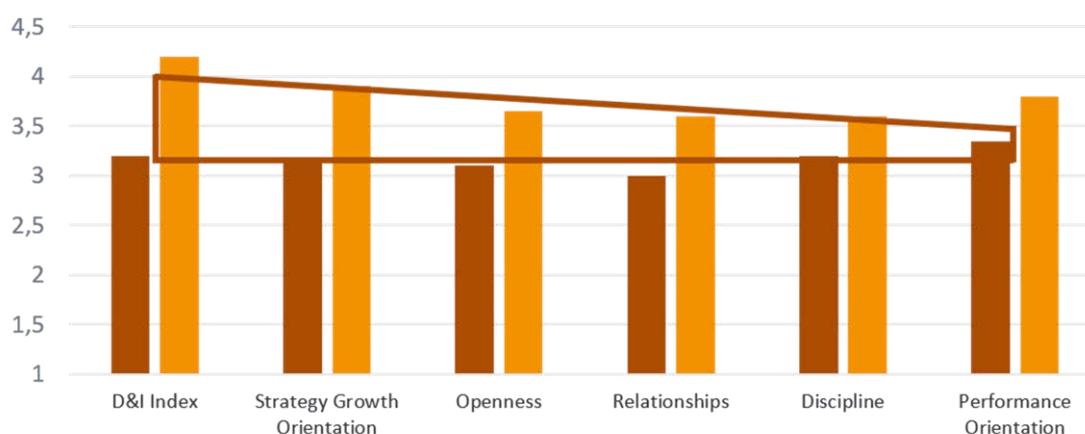
### 3 The Russell Reynolds Associates survey

The need for Diversity & Inclusion (D&I) is substantial and growing in all industries, including chemical companies. This finding was substantiated in a Russell Reynolds Associates (RRA) survey called *Diversity & Inclusion as Key Success Factor of Corporate Culture*, conducted in 2016 by Dr Joachim Bohner, Ms Franziska Funk, Ms Saskia Schwering and Dr Thorsten Bauer. This survey went beyond looking at diversity as tied to demographics such as gender, but rather as a holistic concept, incorporating both visible demographics as well as more implicit aspects such as diversity of thought, willingness to engage in true debate, and openness to different employee needs.

They analyzed the responses of more than 5,000 executives and arrived at meaningful results regarding the current and future significance of diversity in companies. The findings are based on the online-assessments (Culture Analyst™) about the perceived current culture, and the desired culture crucial for the future strategic success of the assessed managers' respective company. In total, the authors analyzed data from 119 companies.

Importantly, diversity was not only valued by managers – it was the key area that presented a need for a real and lasting change in corporate culture. The RRA survey showed that diversity and an inclusive management approach are "the most desired factor" of corporate culture compared to all other dimensions (see figure 1). Interestingly, it also

Figure 1 Current and desired aspects of corporate culture (source: own representation).



presented the largest gap between current perceptions and desired levels of D&I. The researchers concluded that D&I is a key aspect of company culture has been vastly undervalued to date. To close this gap, leadership needs to consider what can be done to bridge the current and desired levels.

These results confirm the findings of the aforementioned studies, showing that companies with a strong diversity culture have a considerable advantage in hiring and retaining qualified staff – they are deemed more attractive employers than companies not paying much heed to diversity. In addition, these results accentuate the magnitude of importance of Diversity & Inclusion compared to all other factors that make up a corporate culture. This striking insight is still often underestimated in its consequences. Looking ahead, most executives now expect their companies to focus on implementing D&I initiatives with more tenacity, meaning they see this topic as the area with the largest need for attention. This makes D&I the central aspect to focus on when transforming corporate culture.

How to address the need for a change in corporate culture? Start at the top, by identifying and promoting those leaders who can bring D&I to life. In the past, organizations have invested time, money and resources in communication, training, and development methods that are not aligned with the necessary leadership requirements of today to foster D&I. Numerous analyses done by Russell Reynolds Associates have shown that old, out-dated recruitment and promotion methods and one-dimensional evaluation screens no longer suffice: they cannot adequately predict a top manager's chances for success. What is needed in today's ever-changing and dynamic world is the ability to make best use of diversity in all its forms, leveraging these differences in an inclusive way, and thereby staying abreast of the changes in, and exponential complexity of the business.

Selection was – and often still is – based on how sizeable the performance drive is, how pronounced strategic skills and persuasive prowess are. Executives were cultivated and deemed champions of future success because they had the attributes believed to be vital: great dedication and commitment, straightforwardness, resilience, power, and intelligence. Obviously, these factors are not suddenly unimportant, but anybody wanting to be and stay successful can no longer afford to lead based on these one-dimensional qualities or rely solely on past strengths or assets.

A new kind of manager is needed, one that can join, link, unite and process internal paradoxes. This

new manager must advance heroically while remaining vulnerable, in as much as s/he must be able to question herself/himself. S/he must be prepared to take risks but must also be hesitant without, however, always wanting to defensively justify what was done. Permanent introspection is required, as is a willingness to reflect on whether the propensity to take risks may be too great and could endanger the company. The new manager must be strategically minded and sufficiently pragmatic to facilitate synchronising elevated targets with the company's capabilities. Overall, managers must be able to adjust to different situations and employ seemingly contradictory styles based on the problem at hand. What enables the new manager to bridge these gaps is having a diverse and multi-faceted personality.

When thinking through this concept of a leader with a diverse personality to its conclusion, one finds that such leaders can have the kind of effect on corporate culture that will be crucial for future success. They can create a "diversity of thought" culture, which many analyses (among them studies done by Deloitte, McKinsey, or the Harvard Business School) have determined to be the most important future success factor for companies. The ability to think and operate diversely encourages and benefits the D&I aspect in all its facets. On this topic, Dr Joachim Bohner, managing director for leadership and succession at RRA, carried out intensive research. Leaders with diverse personalities in top-management teams, that can and will create diverse corporate cultures, are accordingly every company's most crucial element in achieving and ensuring a successful future.

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Manuscripts may be submitted for consideration as research papers, papers for the practitioner's section or as commentaries.

All submitted manuscripts should contain original research not previously published and not under consideration for publication elsewhere. Papers may come from any country but must be written in American English.

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Authors are required to submit manuscripts via e-mail ([submit@businesschemistry.org](mailto:submit@businesschemistry.org)). Please prepare the text in Microsoft Word or rtf-format. When submitting a manuscript, please include the following information:

- Information about the authors (affiliation, postal address, e-mail address)
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Additionally, please stick to the formal requirements presented below, especially concerning citations and graphics. Manuscripts disregarding the guidelines may be returned for revision prior to any reviewing activity.

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Manuscripts can be arranged in the following order:

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- Results
- Discussion
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These guidelines are, however, flexible, especially for case studies. To structure your manuscript, please try to restrict yourself to a maximum of three levels of headlines.

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**Thank you for your contribution!**

