Green chemistry

The new 'currency'

The paints & coatings industry is undergoing a shift since the 1990s with green alternatives becoming the norm, whether it is about chemistry or processes. Looking at this shift, it appears that green is becoming the currency in a new economy - the green economy. The question economists are asking is whether new energy technologies and green chemistry can replicate the success of information technologies in boosting productivity of the industry.

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Beginning in 1995, productivity began to grow at a much faster rate than it had in years. The jump first seen in 1995 was initially viewed as an anomaly, but productivity continued to rise over the next several years. As economists scrambled to figure out why, entrepreneurs raced to take advantage of the new economy. Although, it took economists several years to find out exactly what was driving the jump in productivity, it is now clear that the decreasing cost of computer hardware and software dramatically increased the role of information technology (IT) in the economy during the 1990s. Even though IT spending represented three per cent of GDP, it was having a tremendous impact, particularly in the US. IT probably accounts for almost all the growth in productivity in the boom of the 1990s, and it is still perking right along.

Environmental regulations

Paints are typically applied to protect and enhance the appearance of a surface. Solvents in the coating facilitate applications and assure a smooth finish, but were not part of the final coating. Eventually, the solvent evaporated from the coating was either captured and controlled or was released as air emissions. When exposed to sunlight, these volatile organic compounds (VOCs) contributed to the formation of tropospheric (lower atmosphere) ozone. Regulations aimed at reducing tropospheric ozone levels targeted precursors including VOCs. With the passage of several regulations in the 1960s and 1970s as well as the US Clean Air Act Amendments of 1977, users of industrial coatings began to be regulated in the US. While the US led other industrial countries in regulations of coatings applications, Europe also adopted similar regulations in the late 1980s, and some of the environmental most stringent regulations are found there.

Green chemistry and engineering

The paints & coatings industry has been following different strategies as a means to designing chemical products and processes that eliminate the use and generation of hazardous substances. Environmental regulations motivated raw materials suppliers and paint manufacturers to think about new approaches. Some of these approaches are: switch to alternative technologies; reformulate; and install control or recovery technologies. It has endorsed the concept of green chemistry and green engineering.

Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. It was first to promote pollution-prevention strategies by encouraging chemical companies to use alternative chemical feedstocks, solvents & synthetic pathways that reduce waste and improve energy efficiency. Green engineering is the development & commercialisation of industrial processes that are economically feasible and reduce the risk to human health & environment.

Both green chemistry and engineering are based on the premise that it is better to prevent waste than to clean it up after it is created. The principles of green chemistry and engineering now serve a cross-cutting role throughout science & engineering by prompting researchers to efficiently utilise raw materials and avoid toxic and/or hazardous reagents & solvents.

How to do it?

Where does a chemical product or process lie on the green spectrum and how well might it contribute to or detract from sustainability? Its impact on resource consumption and on the environment must be quantifiable. Researchers have developed a host of cradle to grave analyses and metrics that go beyond production of a chemical or product to include how its raw materials are procured, how the product is used, and how it is recycled or disposed of. Life-cycle analysis includes the associated costs for all phases of a product's lifetime such as energy and transportation.

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These analyses serve as accounting tools for comparing the total environmental and economic impact of products from different processing routes and under various conditions. They allow scientists to peel back the layers of their processes to see how subtle changes in solvents, water usage, raw materials, catalysts and process equipment can make a difference. Even at a nominal disposal cost of Rs 20 to 30 per kilogram of waste in India, or $ 100 per kilogram in the US, the potential annual savings of waste avoidance are significant. The important contribution of such metrics is that the chemical industry is now seriously thinking and talking about green chemistry and sustainability.

Some argued that green chemistry is an academic exercise that would be cost-prohibitive. For example, some chemical companies recently have been pushing 'sustainable chemistry,' which refers to a company's sustainable bottom line, as an alternative to green chemistry. However, the proponents of green chemistry assert that green chemistry is sustainable chemistry. In fact, many green technologies already in place are the chemical industry's resounding endorsement of green chemistry.

It is estimated that out of all chemical products and processes in existence, perhaps only 10 per cent of them are already environmentally benign, that their production, use, and end-of-life disposal have little environmental impact and little drag on sustainability. May be another 25 per cent could be made environmentally benign relatively easily. The other 65 per cent needs to be invented or reinvented. There is still a long way to go, but scientists have asserted that green chemistry is how this can be done.

Reduction in VOC

Paint suppliers hoped to provide formulations, which used less amounts of solvent, and thus, could be used without control equipment. Therefore, without being directly regulated themselves, paint suppliers were dramatically affected by the regulations. As suppliers working under existing competitive systems, the paint companies had strong incentives to provide low-cost solutions to their clients' regulatory requirements. In early 1990s, various surveys indicated that regulations had an impact on the amount of VOCs emitted by the industry. The reduction in VOCs has been the single highest preoccupation for paints manufacturers, and their raw materials suppliers, particularly in North America and Western Europe.

Globally, the VOC reduction efforts account for 48 per cent of efforts to make paints and coatings greener (Figure 1). When evaluating the VOC reduction efforts on a more regional scale we can detect that there are some differences. In Figure 2, it can be clearly detected that the traditional strong regions also have the largest emphasis on VOC reduction efforts. Despite their leading roles in the quest for environmental solutions, they continue to lead the efforts.

The characteristics of innovations in the paint industry have implications for any other regulated area. Here, as in many other areas, the innovations have not occurred within the regulated industry itself. Instead, new approaches were developed by suppliers atleast one step up the value chain. In the case of new resin systems, novel developments were several steps upstream. These upstream industries must choose how to dedicate scarce resources. They will dedicate these resources to methods of low-cost environmental compliance when the regulations are structured to allow creative methods.

Innovation in paints and coatings

Environmental regulations and enforcements have spurred environmental innovation. It has pressurised companies to innovate, thereby stimulating growth and competitiveness. It is accepted today that with all the environmental regulations, innovation is more likely to occur when market-based approaches are used. Unless innovation is needed for technological reasons in order to meet regulatory standard that is otherwise unachievable, innovation is also likely to reduce the cost burden associated with meeting more stringent regulations.

It has been found that stricter environmental regulation (as measured by industry-wide environmental expenditures and the level of government enforcement effort) results in an increase in environmental innovation (as measured by environmental patents). The fact that environmental innovation has occurred does not necessarily imply that industry profits have increased. This may be due to the fact that within an industry, there are some winners and some losers. Those who have benefitted have seen their R&D expenditures for environment-friendly solution increased, and the overall productivity also increased (Figure 3).

The intensity of innovation cannot be solely attributed to tightening regulations. Instead, changes in market conditions or regulations are responsible for a shift in the optimal mix of R&D projects rather than an increase in overall R&D. The environmental regulations were not enacted to spur innovation. It is, however, generally accepted among the economists that R&D intense firms capitalised on new regulations to develop innovative solutions to respond to regulations and meet customers' needs.

Water-borne coatings are the primary choice for manufacturers as well as end-users in the architectural paints. Back in 1992, The Glidden Company was the first to introduce VOC free paints and primers for architectural applications. Those days, these types of paints did not attract consumers because of their high costs than conventional water-borne paints and marketing approach. Subsequently, many more companies invested research resources in developing zero to low VOC coatings. Water-borne coatings contribute today about 60 per cent of sales, primarily in the decorative segment, making this technology the largest environment-friendly type of coatings. High solids are the second largest types of coatings. The third, but the fastest growing, is the powder coatings. These two are used mostly in industrial segments.

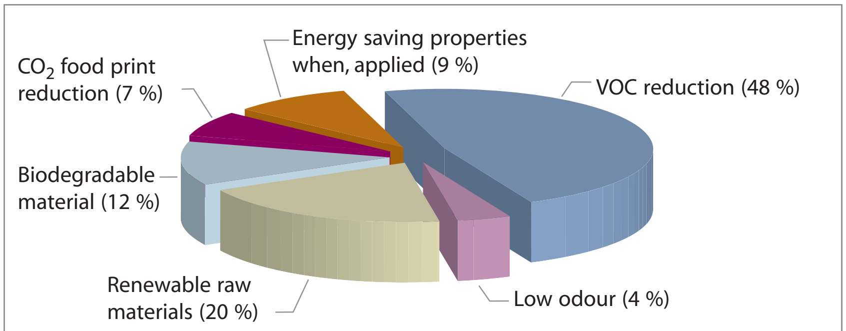

Figure 1: How coatings are made greener

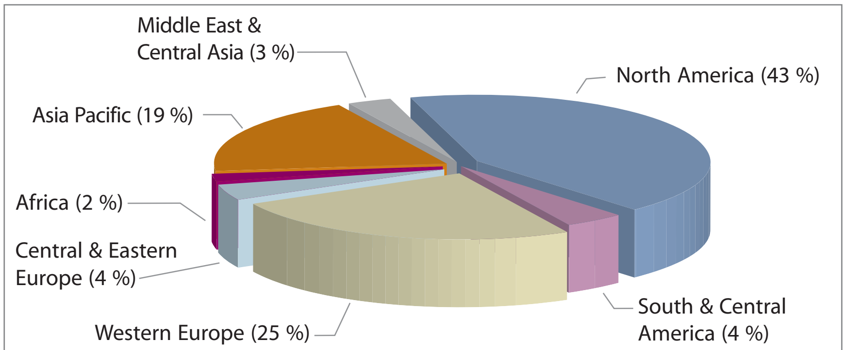

Figure 2: Regional focus on VOC

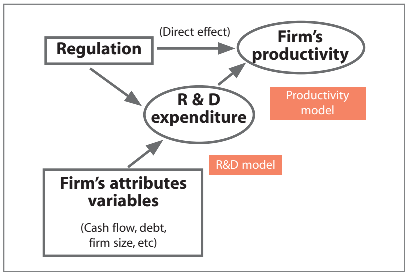

Figure 3: Regulations have positive effects on productivity

Biotechnology: An opportunity

While reduction in VOC is the major focus, because of the regulatory pressure, other strategies include bio-based chemistries and renewable resources. It is estimated that nearly 40 per cent of the manufacturers have expressed interest or have planned a project to evaluate bio-based materials. Innovation scores a sustainability point by substituting renewable resources for non-renewable ones. Some renewable materials are used as monomers in the manufacturing of water-based coatings. The use of castor oil-based monomers or soya oil-based monomers as partial substitution of petroleum-based acrylic monomers has been explored by many researchers. In addition, the use of epoxidised soya bean oil in radiation cure coatings also has been explored. Vegetable oil is abundant and is inexpensive.

Modern biotechnology has the potential to fundamentally transform chemical processes and products. Its application is likely to grow more than ten-fold over the next decade. Companies with vision and aspiration will drive the speed of development. There are a number of examples of biotech-based processes and products involved in the manufacture of paints and coatings that are already available.

Biopolymers as substitutes for synthetic polymers, enzymes and modified additives in specialties, and modern fermentation as a production process for basic and intermediate organics are some that can be cited.

Conclusion

The industry has made the shift since 1990s. It has embraced sustainable concepts. With additional regulations in the horizon, the industry will probably totally convert to green. The future of green technology is bright because its ultimate goal is to support a sustainable world by producing environment-friendly products. However, like any other technology, green technology holds many opportunities and challenges for its stakeholders. For example, consumers are looking for products that are not only eco-friendly but also provide better performance at the same cost.

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How to recycle and reuse are critical concerns for the manufacturers in product design and development. Building new pathways will require not only accelerating the rate of innovation but also creating pragmatic social partnerships between scientists and engineers, research funding agencies, entrepreneurs, product developers, manufacturers, consumers, consumer advocates, regulators, environmental activists and educators.

It is true that the green innovation in the paint & coatings industry has been mainly driven by federal regulations. Today, however, a large number of raw material suppliers and manufacturers are voluntarily adapting the green trend for their products. This is coupled with the growing consumer demands for safer and healthier products.

The concept coming to the forefront of the public is that 'green is not only good for business, but also for the betterment of mankind'. Government initiatives may eventually encourage or even mandate that all manufacturers shift towards implementing green technologies. Thus, in the not too distant future, the green trend would become the rule rather than the exception. The situation today is somewhat different from that of IT, where market demand drove the use and implementation of it in the 1990s.

Today, in the green arena, a lot of these alternative energy technologies are not commercially viable yet without a subsidy. We recognise the government role. It had invested in IT early on in the basic research, which led the development of web. It may still be a long way, but good progress has been made, and the shift is happening, although few experts believe that renewable energy and feedstocks based on renewable sources will be cheap and reliable enough to replace current technologies on a large scale any time soon.

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