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SMART CITIES WILL NEED CHEMISTRY

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Abstract

A smart city is a sustainable and efficient urban centre that provides a high quality of life to its inhabitants through optimal management of its resources. Chemical industry has a key role to play in the sustainable evolution of the smart cities. Additionally, chemistry is at the heart of all modern industries, including electronics, information technology, biotechnology and nano-technology. Chemistry can make the smart cities project more sustainable, more energy efficient and more cost effective. There are six broad critical elements of any smart city: water management systems; infrastructure; transportation; energy; waste management and raw materials consumption. In all these elements chemistry and chemical engineering are deeply involved.

Key words: smart cities, critical elements, chemistry, chemical engineering, sustainable development

1. Introduction

A smart city is a sustainable and efficient urban centre that provides a high quality of life to its inhabitants through optimal management of its resources [1]. The smart city concept isn't static: there isn't an absolute definition of a smart city: there isn't a final point, more rather is a process or a set of ways whereby the cities become more habitable, and more able to respond to the new challenges.

Today, almost 75% of European citizens live in cities and this trend will continue. To succeed in creating sustainable and healthy cities, the Covenant of Mayors was launched in 2008 to support local authorities to implement sustainability policies. Currently, 4.418 cities have committed to meet the 20-20-20 objectives (20% reduction in emissions, 20% renewable energy and 20% improvement in energy efficiency) by 2020 [2, 3].

The smart city must have the next attributes: smart buildings, smart infrastructure, smart technology, smart energy, smart mobility, smart citizens, smart administration, and smart education.

Critical aspects of a city such as managing resources, stabilizing pollution levels, allocating energy are traditionally calculated independent of each other. There is an opportunity in putting together a holistic blue-print and making these cities into a tangible reality. Chemical industry has a key role to play in the sustainable evolution of the smart cities. The chemical industry is the energizer of economic development. Additionally, chemistry is at the heart of all modern industries, including electronics, information technology, biotechnology and nano-technology. A closer look at these building blocks of value-chain would tell us that chemistry can make the smart cities project more sustainable, more energy efficient and more cost effective. On a macro-level, there are six broad critical elements of any smart city [4]:

- Water management systems;
- Infrastructure;
- Transportation;
- Energy;
- Waste management;
- Raw materials consumption.

Let us examine how the chemicals industry can contribute to each one of these and make them not just economically viable but also environmentally sustainable.

2. Critical elements of smart cities

a) Water management systems

Water is essential for life. As the world's population grows and the effects of climate change become apparent the demand for clean water increases. Too many people around the world still

do not have access to pure water or adequate sanitation. The water key challenges are [5-7]:

- Scarcity of water as a resource - the water quantity and quality challenge.
- The water / energy nexus – we need water to produce energy and water uses large amounts of energy in its supply and transmission systems.
- Unsustainable waste water treatment systems.
- The extra demands for water in the development of the bio-based economy.

The European Innovation Partnership on Water [8] has ambitious some examples are: to reduce private water consumption, increase water efficiency in irrigation, decrease the water footprint of all industries, minimize water loss in distribution systems and reduce the energy used in the water sector. The innovation initiative also aims to increase the reuse of water, introduce low water consumption processes into industry and promote new techniques such as nanofiltration. In addition it will examine eco-systems, land-use management and adaptations to climate change.Sustainable water treatment solutions, recycling, water discharge facilities and providing a 24x7 water supply are few areas where the expertise of the chemicals industry provide thrust to economically viable solutions.

b) Infrastructure

In development of infrastructure, the construction and coatings industry has taken several gigantic leaps in the past few years. Energy use in buildings accounts globally for nearly 40% of energy consumption and 36% of total energy-related carbon dioxide emissions, according to Intergovernmental Panel on Climate Change. In the UAE, air-conditioning contributes to 65-70% of electricity consumption [9]. There are a range of key chemistry-enabled solutions [2, 4] for initiatives in the area of building energy efficiency into smart cities including:

- High Reflectance Indoor Coatings: reflects lights better than normal paints and maximize the feeling of space and illumination, reducing our artificial lighting cost.
- High Reflectance and Durable Outdoor Coatings: when applied to roofs and walls reflect sunlight radiation and reduce roof and wall temperatures, leading to significant energy saving for the cooling of spaces.
- High Performance Insulation Foams and Vacuum Insulation Panels: when adopted can reduce your energy heating cost from 30% up to 80%.
- Phase Change Materials: enables walls and ceilings to absorb and store excess heat during the day and dissipate it at night, thereby moderating the household temperature to keep it more pleasant and comfortable throughout the day.

Chemical industry is promoting these measures using its own traditional communication channels with the market, but an active positive role of the local government could speed up adoption substantially.

c) Transportation

Development of smart cities involves increasing the percentage of the use the public transport for the aims of greater energy efficiency, higher safety norms and lower exhaust emissions [9]. Also, it is desirable to reduce the weight of public transport vehicles [9]. Presently, a vast range of composite polymers are available for light-weighting of vehicles. Light weighting techniques use lower density foams that stand up to different kinds of weather, fluctuations in temperature, variation in humidity levels. Furthermore, with deployment of specific elastomers - vibrations can be reduced and we can enable noise-free transportation.

d) Energy

There are several ways supported by chemistry in order to reduce energy consumption in the smart cities [2, 10]. The call for energy-efficient construction materials is getting louder. Because of its excellent insulating properties polyurethanes are used in the production of insulation for prefabricated panels by the construction industry, and in cold chain and wood imitation applications. They additionally offer excellent structural strength, durability and adhesion to laminates and liner materials, which are inherent structural elements for the end products. A wide family of heat transfer fluids delivers the specialized technologies to achieve the optimum combination of stability, efficiency and economy. Utilized widely by retail cold-storage units' world over, these fluids offer a stable replacement to the refrigerant gases hence avoid pollution. Consumption of alternative energy while creating these new spaces appears to be a logical step. Solar panels traditionally use ethylene vinyl acetate components, which are expensive, and not easily available. This creates a barrier to the widespread use of solar energy. However, scientists have been able to create effective alternatives which offer superior performance, while significantly improving cost efficiencies.

f) Waste management

Chemical industry can offer credible solution for sewage treatment problem of the smart cities [11]. The sewage treatment plant, which can use advanced tertiary treatment via ultrafiltration and reverse osmosis technologies, can operate round-the-clock to reuse wastewater and save huge amount of water every day. Treated water can then be utilized for other activities such as air-conditioning cooling, toilet flushing, horticulture, construction, etc.

e) Raw materials consumption

Smart cities are big consumers of many raw materials. Our modern society is dependant on a range of raw materials, including industrial minerals and metals used in high technology applications that support our lifestyle and infrastructures. But many of these raw materials are not easily available. All are an essentially finite resource: we only have one planet to live on.

With increasing world population, the growth of urbanization and the industrialization of emerging economies the availability of some raw materials are becoming critical. This can have both economic and social impacts on our society as the supply of raw materials dwindles and certain technologies are no longer viable. In addition the extraction and processing of some raw materials has significant environmental impact.

Four sustainable solution strategies can contribute to improving the future security of supply for these raw materials. The activities are collectively known as the '4Rs' [8]:

- Reduce – use less of the material to deliver the same product effect.
- Reuse – enable the recovery of a material to deliver the same effect repeatedly.
- Recycle – enable the recovery if a material to be reprocessed with no loss in value.
- Replace – substitute with a material, process, technology or business model that delivers the same (or better) effect.

Any new solution should also reduce the overall environmental impact and be safe to users and consumers. All these solutions will require sustainable chemistry to achieve them and will contribute to the medium to long term security of supply for raw materials. They will also boost resource efficiency and develop new business areas such as advanced recycling processes. The chemical industry is developing new technologies for more efficient extraction of raw materials and works for the most efficient use and recycling of materials. It will also develop substitute materials and alternative technologies for its own and other industrial sectors. A smart city needs simultaneously drastically improving its resource and energy efficiency and also reducing its environmental impacts. We all need to "do more – and better – with less" and chemistry will be the main tool for this.

To achieve the development of smart cities requires new concepts and materials which must be developed for energy (generation, storage and efficiency) in sustainable construction and urban mobility. New materials for smart living are needed that have novel properties for use in environmental technologies such as high efficiency heating and cooling systems, urban transport and water management. Technologies that easily and effectively improve the energy efficiency of the existing housing stock are a particular requirement.

The construction and transport sectors are essential actors in achieving smart cities. And chemistry driven systems are at the heart of improving sustainability in both. Materials created by innovative chemistry such as insulation, adhesives and sealants fulfill an enabling role in construction. Chemistry is the key to new energy systems and lightweight materials that can transform urban mobility and ambient technologies that can combat pollution.

3. Conclusions

To be environmentally sustainable, economically competitive and remain attractive to live in, cities need to reduce their total energy consumption, increase their use of renewable energy, adapt their physical and communication infrastructures, find solutions to inner-city mobility issues – in particular personal mobility - and improve educational and working conditions. For all these purposes chemistry and chemical engineering are irreplaceable tools.

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