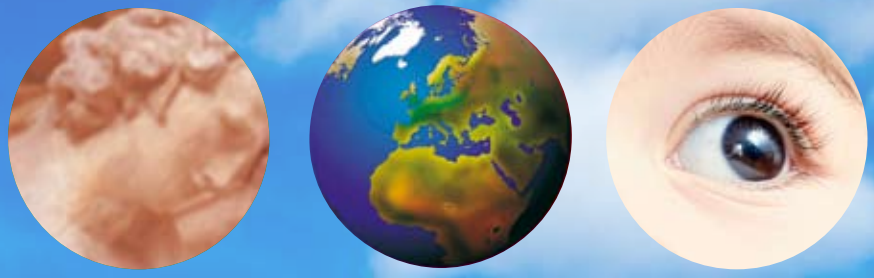


The World in 2030

Summary and Initial Industry Response

Plastics
The Material for the 21st Century

Foreword

Plastics form an important part of everyone's life today, and at Plastics*Europe* we believe plastics will play an even more important role in the 21st century.

However, it is now abundantly clear that the world will face a number of serious challenges in the coming decades: greenhouse gases and their consequences, a rapidly growing and more mobile population, an increasingly tight supply-demand balance for fossil fuels, and a larger proportion of older people in developed countries, to name but a few. At the same time, exciting opportunities are appearing on the horizon: improved healthcare and enhanced longevity, and the promise of a higher standard of living for more people, thanks to globalisation and new scientific developments, such as nanotechnology and human genomics.

The plastics industry has a solid pedigree in driving innovation that has brought benefits to society, and believes therefore that it has a role to play in helping the world to meet these new challenges and make the most of future opportunities. At the same time, we believe it is important that decisions about future actions are made (as far as possible) on the basis of solid scientific evidence and in-depth studies, rather than opinions or incomplete information. That is why, to try to get a clearer picture of what lies ahead, Plastics*Europe* commissioned the eminent British futurologist Ray Hammond to compile a report for us on developments coming up in the next couple of decades. This report – The World in 2030 – has now been submitted, and the Executive Summary is reproduced in this booklet.

Like plastics themselves, the issues raised in Ray Hammond's report touch on so many different aspects of life that we believe any debate on plastics and the future should be wide-ranging and involve as many parties as possible – both within the industry and between the industry, government, NGOs and the public. To stimulate this, we have drawn up an initial response to the report (included in this booklet), based on consultations with a variety of people across the membership. It gives a preliminary overview of the sorts of activities the plastics industry is already undertaking in relation to the changes foreseen by Ray Hammond, and what we might be able to do in the future. In addition, we plan to initiate a number of activities to bring interested parties together and to kick-start discussion. These activities will focus, in the first instance, on three key areas: energy efficiency and climate protection; resource efficiency; and consumer protection.

At Plastics*Europe*, we believe that, by taking a proactive, inclusive approach to the challenges and opportunities that lie ahead, we will be best able to contribute to the creation of a more sustainable world in 2030. We look forward to others joining us in this endeavour.

Wilfried Haensel
November 2007
Executive Director, Plastics*Europe*

The World in 2030

Executive Summary

By Ray Hammond

The speed of technological development is accelerating exponentially and, for this reason, by the year 2030 it will seem as if a whole century's worth of progress has taken place in the first three decades of the 21st century.

By 2030 it will appear as if a mass of dizzying scientific breakthroughs have suddenly been made simultaneously – in computing, in healthcare, in communications, in wealth generation, in materials performance (including smart plastics), in travel and in robotics. In many ways, life in 2030 will be unrecognisable compared with life today.

But not all of the changes in the world are going to be beneficial. Climate change, already the cause of extreme and unpredictable weather around the world, will almost certainly have worsened by 2030. Even if the world magically stopped emitting greenhouse gases today, those gases emitted over the last thirty years will continue to influence the Earth's atmosphere deleteriously until the middle of the 21st century. For this reason, solving the problem of climate change must be seen as humankind's greatest and most important challenge over the next twenty-five years.

Any exercise in futurology is a process of identifying key trends in the present and then extrapolating from them in a systematic way in order to discern how they may affect our future. This approach can yield useful results over a period limited to the next twenty-five years but beyond that point lies a barrier which inhibits our ability to speculate meaningfully about humanity's longer-term future.

Most of the world's futurists, futurologists and computer scientists agree that at some point between 2030 and 2040 a milestone in technological development will be reached that will cause a rupture, a complete disjoint, in human evolution. Around this time we will build the first computer that is the intellectual equal of a human. Because of the accelerating, exponential nature of technological development (fuelled entirely by faster and richer information flows) it follows that a short time after that we will be assisted by our super-intelligent computers to build a machine twice as clever as the most capable human. Shortly after will appear a machine four times as clever as a human, then eight times as clever, then sixteen times as clever, and so on.

This projected point in future human history is called **'The Singularity'** by futurists and futurologists because once super-intelligent machines begin to take over the task of technological development it is expected that progress will be so rapid, and will take such unforeseeable directions, that it is pointless to speculate about life beyond a twenty-five year timeline.

However, it is possible to identify a number of societal, physical, technological and scientific changes that are going to appear between today and the point that The Singularity occurs. These include:

An explosion in **world population growth**. Today there are just under seven billion people on the planet. By 2030 there will be over eight billion and by 2050 the figure will be between nine and twelve billion. How are we going to feed such a large number of people and, even more pressingly, where is the fresh water they need going to come from? How are we going to meet their energy needs?

Changing societal demographics. In 2006, nearly 500 million people worldwide were 65 or older. By 2030 the total is projected to double to one billion – one in every eight people on the planet. A combination of widespread immigration from the less developed world to the rich world, robot carers and computer-generated wealth will provide for this army of elderly people.

Climate change is going to wreak havoc all over the world as the weather becomes more extreme. Urgent and decisive action must be taken if humankind is to escape weather so bad that civilisation itself is threatened. By 2030 Western Europe could be experiencing Arctic-style winters and monsoon summers and vast swathes of land in the equatorial regions, the home to some of the poorest, most hard-pressed people in the world, could become desertified.

At some point between today and 2030 **oil extraction will have peaked and oil fuel for transportation will have become increasingly uneconomic**. It is credibly forecast that the world's energy needs are going to double over the next twenty-five years. With climate change mandating that we must burn the minimum of fossil fuels, where is this energy going to come from? The first response must be to conserve energy aggressively, and here plastics have a vital role to play in providing insulation materials and in improving the overall energy efficiency of vehicles, planes and cargo transportation. The second response must be to harness energy from renewable sources. Wind power, solar generation, wave power and other natural energy sources must receive heavy investment, subsidies and incentives from governments. As a matter of extreme urgency we must harness the natural and wholly renewable energy that surrounds us all.

Globalisation. World income has doubled since 1980 because of globalisation, and almost half-a-billion people have been lifted out of poverty since 1990! If pursued ethically and sustainably globalisation (by which I mean free international trade and capital flows) offers the world the greatest opportunity for peace. Nothing disarms hatred, militancy and would-be terrorists so effectively as prosperity.

There will be a **revolution in healthcare** which will dramatically extend human life spans. A combination of gene-based therapies, stem cell medicine and molecular-nanotechnology will introduce a new model of medical science which will prevent disease from occurring and will offer significant life extension and even physical and mental rejuvenation (at least for the wealthy people in the developed world). A child born in 2030 will have a life expectancy of 130 years (at the point of his or her birth) and, long before they reach old age they will be offered rejuvenation treatments to maintain their biological age at thirty or forty years old, no matter what their chronological age.

Plastics will play a largely increased role in our lives. Plastics are becoming 'smart' and, in addition to high-performance plastics providing bodies for jet aircraft (such as the new Boeing Dreamliner), plastics will be capable of substituting for human blood and the key to building ultra-low-emission cars which will travel 1,000 miles on one gallon of gasoline. Other developments will include plastics that grow on trees, plastics that can include sensors and communications networks, and plastic which knows how to continuously heal itself.

Computer 'personalities' will develop to the point where they become our 'companions'. At first these 'software personalities' will inhabit the devices that descend from today's mobile phones but, as they become increasingly clever, and as the platforms and networks on which they run become ever more powerful and capable, our companions will migrate onto and into our bodies. At first our companions will be in our clothing, watches, jewelry and earpieces. Later they will enter our bodies and reside in plastic nano-scale implants beneath our skin.

By 2030 all **cars travelling on major roads** will be under the control of satellite and roadside control systems and many cars will be driving themselves. Apart from the need to reduce the present appalling global death toll from road accidents – and the need to squeeze many more cars onto crowded roads – automated vehicle and traffic systems will make it safer to travel through the extreme weather systems we are likely to be suffering constantly in twenty-five years' time. All road vehicles will produce very low or zero carbon emissions. Most large cities will operate congestion charging systems and, in countries with severe traffic congestion, road pricing will be widespread.

Robots in all shapes, sizes and forms will be ubiquitous by 2030. In our homes, schools, factories, shops and leisure facilities robots with varying degrees of intelligence (and made largely of plastic) will be our contented slaves, manufacturing wealth, easing our lives, caring for our needs and overseeing our security. By 2030 robots will be producing massive wealth and, as living standards rise rapidly in the developing world China, India and today's other manufacturing nations will, in turn, outsource their manufacturing and service industries to armies of willing, unpaid, untiring robots. By 2030 we will be connected constantly to what, today, we can only think of as a **'super-web'** and that connection will for many be a bio-digital interface. At the very least our senses will be connected to the super-web by microphones and mini-projectors and, perhaps, some of us will have direct neural connections between our own brains and the global networks. Our communications and entertainment will be wholly 'immersory', multi-media, multi-sensory, 3D, holographic and fully tactile, telekinetic and olfactory.

Our **leisure activities** in 2030 will be similar to today's but our time spent in virtual leisure (watching movies, playing games, chatting with each other, exchanging videos, etc.) will be a lot more intense. The multi-media, multi-sensory experience offered by the ultra-high bandwidth 'super-web' of 2030 will produce sensations almost indistinguishable from reality. Soon after our timeline of 2030 humans will begin to attach their senses directly to the super-web and, at that point, virtual experience will be identical to physical experience.

Life will be pursued within **surveillance societies**. By 2030, we too will be part of 'Big Brother's' surveillance team. We ourselves will be videoing our surroundings every moment that we are outside of our homes. This will be for the purposes of personal and family security. By 2030 computer storage systems will offer so much storage space, and cost so little, that the cost of capturing everything will be almost too small to measure.

Retailing. 'Utilities' shopping – buying repeat and routine items – will mostly be done on the networks and will, in some instances, become automated as your 'smart' home environment senses the need for milk, eggs, tissues, washing power and other everyday items. These will be ordered from your preferred supplier and either delivered to your door or left for your collection. 'Discretionary' shopping – the shopping you choose to do – will have become 'retail experiences' in which shoppers will take pleasure in the leisure pursuit of selecting clothes, high-end cars (low carbon), organic fresh food, furniture, etc. To maintain profit margins within their physical outlets retailers are already designing 'themed' shops and it is likely that in twenty-five years high-end retail parks will have become a holiday destination in themselves (like today's Dubai).

Within our societies **inequality** will continue to increase, as it is increasing today. Even though the poorest groups in developed societies have become much better off over the last twenty-five years (and will be very much better off comparatively by 2030) the wealth of the richest in our society has grown far faster. This trend will continue and although the middle-classes will continue to expand and become more affluent, the super-rich will become mega-rich and then hyper-rich. And there will be many more hyper-rich people in the world of 2030.

A **global** brain of immense intelligence and with instant access to the whole store of human knowledge will emerge from Google or from similar search engines (or from all of them combined). By 2030 this global brain will be available to almost every human on the planet and will be accessed by computer, by mobile device, from public spaces and, seemingly, by our thoughts.

The fourth decade of the 21st century will be the beginning of the end of human evolution as it has progressed over the last two million years. As machines surpass the intellectual capacity of humans they will become a companion species on Earth with the potential to become humanity's successors. But, as genetic medical techniques allow humans to alter their own biology, individual humans will have the ability to enhance their physical and cognitive abilities and to greatly extend their longevity. Humans will also have the ability to interface at a neural level with super-intelligent machines. How these developments will affect the future of human evolution cannot yet be discerned with any confidence.

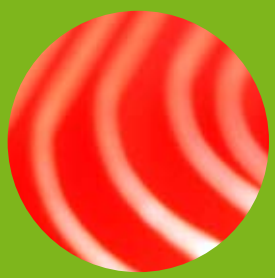
Ray Hammond
November 2007




Summary and Initial Industry Response

By Plastics*Europe*



Population growth

Plastics can help combat the problems caused by the projected rapid growth in the world's population in at least two key ways:

- Combating shortages of food
- Combating shortages of drinking water

Combating shortages of food

Keeping food safe

One of the most familiar ways plastics already help us to make the most of the food we have is through packaging. Plastic film keeps perishable food fresh and safe for longer, while plastic packaging protects food from damage during transportation.

Up to 50% of food is currently wasted in developing countries. Although this is partially due to a lack of refrigeration (due, in turn, to a lack of electricity), it is also because plastic packaging for food is hardly used. Compare this with a mere 3% of food wasted in developed countries, where refrigeration and plastic packaging are commonplace.

The future? We expect to see packaging become intelligent, thanks to multi-functional plastic films and surfaces that can detect and indicate to the consumer the condition of the product, and small, inexpensive chips (RFIDs, based on conductive polymers) that are thin enough to be printed on film. Such 'smart' packaging will alert shopkeepers and customers to any temperature changes that may affect the integrity of the product, or when sell-by dates are approaching. Similar chips may help in food preparation, telling the consumer when food has been properly cooked and can be safely eaten.

Maximising crop yields

Plastics can also help by creating the right conditions for optimal food production where those conditions are not naturally (or cost-effectively) present.

- Plastic greenhouses and plastic tunnels enable food to be grown under cover in places which are either too dry, cold or otherwise infertile. They also enable multiple harvests, resulting in increased yields (e.g., in southern Spain).
- Ensilage film protects hay, for instance, in the fields.
- New, photoselective plastic films can filter light of specific radiation wavelength, enabling growers to optimise crop development.
- Where no soil is available, crops can be grown hydroponically, i.e., with their roots in mineral nutrients contained in a plastic bag or container.
- Plastic water pipes in computerised irrigation systems allow water to be distributed without leakage in precise quantities, thus contributing to resource efficiency.

The future? In the next two decades, we envisage that the plastics industry will develop more specialist films for the food and agriculture industry to maximise yields and enable growth in less than favourable conditions. The production of meat, being energy-intensive, offers a different challenge. Could plastics offer any energy-saving solutions here? And given that farming often takes place in rural areas that are also an important tourist amenity, the plastics industry will need to take not only functional factors but also aesthetic factors into account.

Combating shortages of drinking water

Keeping drinking water safe

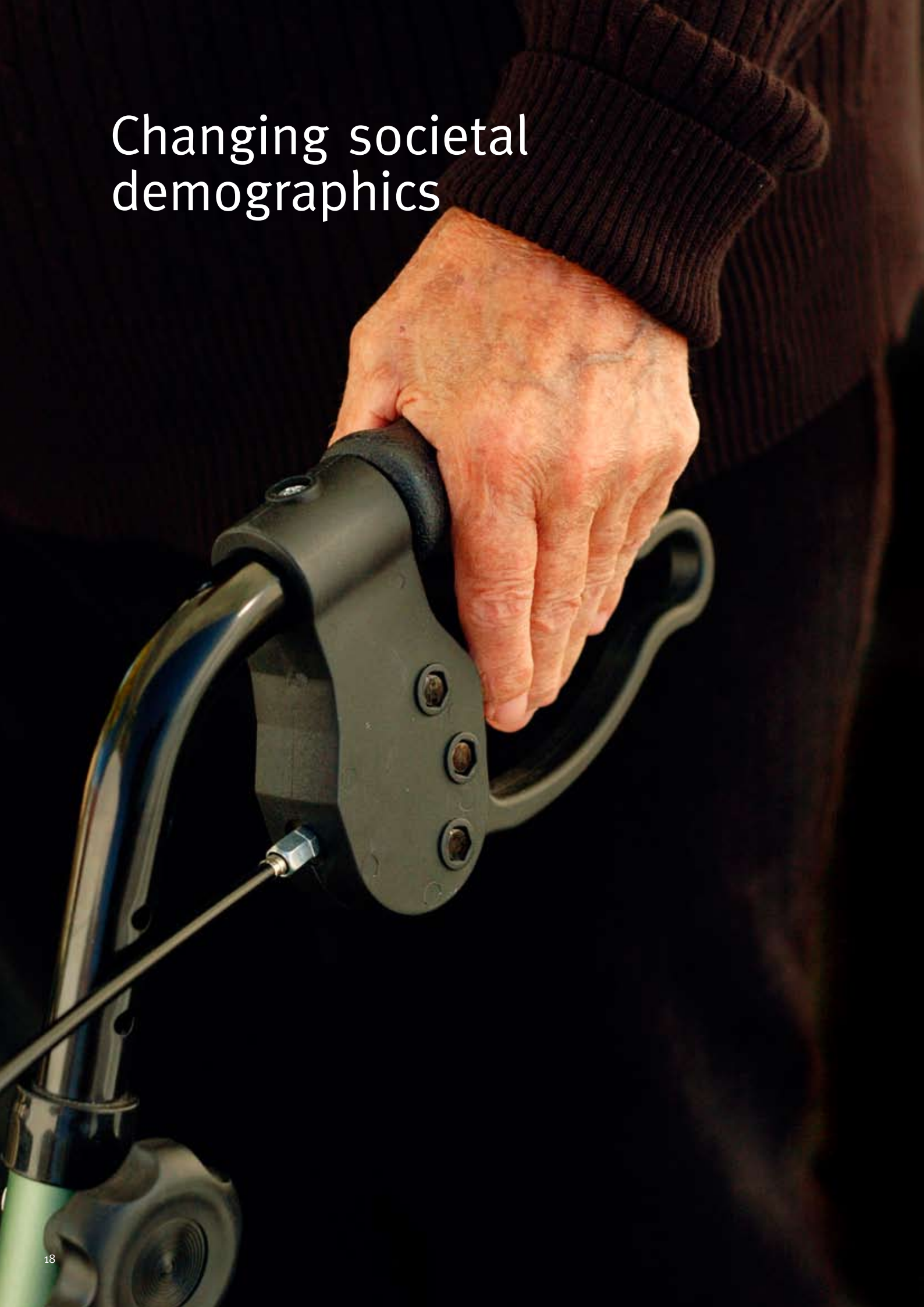
A lot of drinking water is lost through leakage from old pipe systems, made of traditional materials: plastic pipes, however, are virtually leak-free, and do not deteriorate. They also safeguard the quality of the water flowing through them, as they do not allow any uptake of sewage water or other soil contaminants. Similarly, plastic liners for reservoirs ensure that the water does not seep away. The use of plastic pipes in waste and sewage systems also reduces the chance of leakages contaminating ground water. And if water is contaminated, plastic filters (initially developed for use in space vehicles) can make it drinkable again.

Creating drinking water

Extra fresh water can be created by the desalination of sea water. Plastics play a significant part in reverse osmosis desalination. This process makes use of a plastic nanotechnology water desalination membrane and plastic pipe systems that need to perform well for a long time under harsh salty conditions that would challenge most other materials.

The future? Often, some areas have too much water, while others have too little. To solve this problem, we envisage durable plastic piping systems that could be created in situ, enabling water grids – even 'super grids' – to be established, transporting water, say, from northern Europe to southern Europe, much as we transport gas or oil today. Plastics for pipes and containers in such systems will have microbicidal properties, thus helping to avoid contamination of standing water by germs.

Changing societal demographics



Plastics have a useful role to play in responding to the needs of an ageing population. Today, the major contribution made by the plastics industry to the needs of the elderly probably lies in the field of healthcare (which we discuss later). But as the average age of the population increases, the plastics industry will inevitably come up with many more products specifically aimed at making older people's lives more fulfilling.

The future? We envisage the development of more plastic products that take account of the ailments that typically come with age (e.g., reduced mobility, painful joints and impaired faculties): such products would above all be easy to open, easy to use and lightweight. We can also imagine more ergonomic plastic products to enhance the comfort of those who stay at work longer.

At a more high-tech level, plastics will play an important part in the robots (including 'intelligent furniture') that will increasingly be developed to provide care services in the home, not only for the elderly but also for the disabled. Plastics will continue to be a key material in communications, driving further miniaturisation, so that products (mobile-phone earpieces, for instance, perhaps combined with hearing aids) will increasingly be 'one' with our bodies.

Climate change

Plastics can help us deal with climate change and its consequences in at least two important ways:

- Reducing the need to use fossil fuels
- Safeguarding people from the effects of climate change

Reducing the need to use fossil fuels

A major source of greenhouse gases in the environment is the burning of fossil fuels. Plastics have an important role to play here in:

• **Reducing the consumption of fossil fuels for industrial and domestic purposes.** Most fossil fuel is used to generate electricity and heat. Since plastics make very effective insulation materials for buildings, pipes and industrial installations, they significantly reduce fossil fuel consumption. In fact, during their life cycle, plastic insulation materials save 150 times the energy used to produce them. In addition, under adequate conditions, energy recovery from used plastics also constitutes a clean and efficient source of heat energy and electricity.

• **Reducing the consumption of fossil fuels in transportation.** This is happening in several ways. One is by making vehicles (cars, trucks, planes and ships) lighter, with high-performance plastics replacing the use of heavier, traditional materials. The Boeing 787 Dreamliner airliner is a recent example of what is possible: almost half of it is made of plastic composites that are lighter and more durable than aluminium. As a result, the Dreamliner uses 20% less fuel than comparable conventional planes. In addition, by replacing traditional packaging with lightweight plastic packaging, cargoes are made lighter. Fuel consumption can also be reduced by improving the performance of vehicles on the road. Normally, as tyres turn, friction arises between the tyre and the road surface, creating rolling resistance, which in turn requires extra fuel to overcome it: this resistance can be reduced by adding plastics to the rubber.

The future? The full-plastic car is a dream that may come closer to realisation in the coming two decades, although it is unlikely to be achieved by 2030. Plastic bodies may certainly help to reduce the 'CX factor', the drag-effect that wind has on a car's body. Polymers are already added to bitumen used in road surfaces to improve viscosity: might they also help to make road surfaces smoother, and therefore reduce fuel consumption? We could also envisage other forms of propulsion being possible for certain modes of travel: some people are already working on a wind-powered towing kite propulsion system for cargo vessels, with the kite made of high-strength, weather-resistant plastic fabrics, for instance.

Safeguarding people from the effects of climate change

Besides dealing with what seems to be the main cause of climate change, the emission of greenhouse gases, we will also need to find ways of living with the consequences until the problem subsides. One of these consequences is extreme weather and rising sea-levels. Plastics can help here by:

• **Strengthening buildings and flood defences.** Extreme and unpredictable weather is likely to damage housing and other infrastructures. Advanced plastic composites are already used to make buildings in earthquake zones more resistant to damage. In the same way, they may be used to protect buildings against violent storms. Plastics are also used to reinforce the stone ballast revetment for dikes that protect the dike by absorbing the force of the breaking waves, slowing down the water masses. This combination of plastics and stone creates sturdy, porous and highly resistant defences.

• **Enabling continued use of land area during flooding.** Normally, flooded areas of land have to be abandoned until the floods subside. Besides the personal cost, this upheaval can also cause serious economic losses. A potential solution to this problem is currently being explored in the Netherlands in order to protect market garden nurseries located in low-lying areas: securely moored plastic greenhouses are made so that they can float when water levels rise, and settle again when floods subside.

• **Helping refugees.** Plastics will also continue to play a large part in any flood refugee relief operations, with effective infrastructures that are easy to transport, install and maintain, including field hospitals, tents, boats, water-resistant clothing, packaged food, and systems for transporting and storing water and energy.

The future? We envisage the floating of plastic houses and other buildings to become a generally accepted means of coping with flooding, using materials currently used for ship and boat hulls. Like ships, the buildings could be either static (i.e., anchored) or mobile (i.e., motorised), with flexible detachable utility connections. People in some areas may need to learn to live on natural or artificial islands. Certainly, plastics have many of the ideal qualities required to make such artificial islands a sustainable proposition: lightweight, waterproof, rotproof, temperature-resistant, cost-effective and easy to work with. We also expect to see the development of intelligent building structures that can monitor their own internal stresses.

Energy shortages

Plastics can help to alleviate the looming energy crisis that Ray Hammond foresees in at least three ways:

- Improving the energy efficiency of homes and workplaces
- Facilitating the search for more fossil fuel resources
- Supporting the search for a new energy mix

Improving the energy efficiency of homes and workplaces

Plastics already help to reduce energy consumption of both new and old homes and industrial buildings. Most obviously, they improve insulation, saving on heating or cooling costs.

The future? We envisage more plastics being used in the construction industry, with plastic increasingly used together with other materials to raise the energy efficiency and comfort of buildings. This will certainly be the case if calculations that improved building insulation alone could deliver 20% of the EU's target reduction in CO_2 emissions are correct.

Facilitating the search for more fossil fuel resources

It is quite possible that the resources of oil and gas are not actually as depleted as they seem at present. Moreover, if prices increase when the supply-demand balance becomes tight, the extraction of reserves not previously economically viable may become a commercial proposition. Currently, polymers are used to improve the viscosity of heavy crude oil, making it easier to extract, while water-soluble plastics have been used for decades in slurries to press oil out of existing sources.

The future? We would expect plastics to play an increasingly significant role in the commercial extraction of existing fossil fuel resources.

Supporting the search for a new energy mix
To ease a tight supply-demand balance for fossil fuels and, increasingly, to complement such fuels, alternative, renewable sources of energy will be needed. Plastics can play a significant role in facilitating many of these.

• **Wind energy.** Wind energy is currently being harnessed through industrial wind power units, with critical components made of strong, lightweight and durable plastic. Non-corrosive plastics are also playing a major part in the construction of turbines for use in offshore wind farms.

• **Solar energy.** Increased efficiency will make solar panels (mostly made of plastics) of even greater use in warm climates and of practical use in more temperate latitudes.

• **Geothermal energy.** Plastics are also used in the collection of the Earth's natural heat. The geothermal pipe that is installed underground is typically made of plastic, offering strength, flexibility and durability, while allowing heat to pass through efficiently.

• **Hydrogen energy.** Scientists are still working on the development of a polymer electrolyte fuel cell that uses electricity generated by a chemical reaction between hydrogen and oxygen. Such a fuel would entail virtually no emission of greenhouse gases. The main problem is making the transportation, distribution and storage of hydrogen safe for use in everyday life.

The future? We expect plastics to continue to play an increasingly important part in the development and exploitation of renewable, complementary sources of energy in the next twenty years, with plastics innovations enabling renewable resources to follow Moore's Law in the rapidity with which developments take place. More sophisticated, but cheaper, solar panels, for instance, will be built into double-glazed windows in buildings and cars. Panels will be made dirt-repellent to maintain maximum effectiveness. Large cable systems, insulated with low-loss plastic and connected in a 'super grid', will enable energy to flow from warmer to cooler areas or from day zones to night zones.

Globalisation

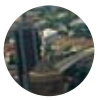
Globalisation, if pursued fairly and ethically, could pull a billion people out of abject poverty, lead to improved living conditions in the developing world, and stimulate global economic growth. The plastics industry has a significant role to play in globalisation in at least the following areas:

- Creating jobs
- Facilitating mobility and communications

Creating jobs

Plastic production is a highly capital-intensive but low labour-intensive business. For logistical reasons, it is obviously best located close to where the feedstock and/or the technology are to be found. Plastic processing (or conversion), however, is just the other way around: it is an industry that requires little initial capital, is labour-intensive and is not as tied to a particular location. This makes processing an excellent industry for developing and stabilising economies, creating local jobs.

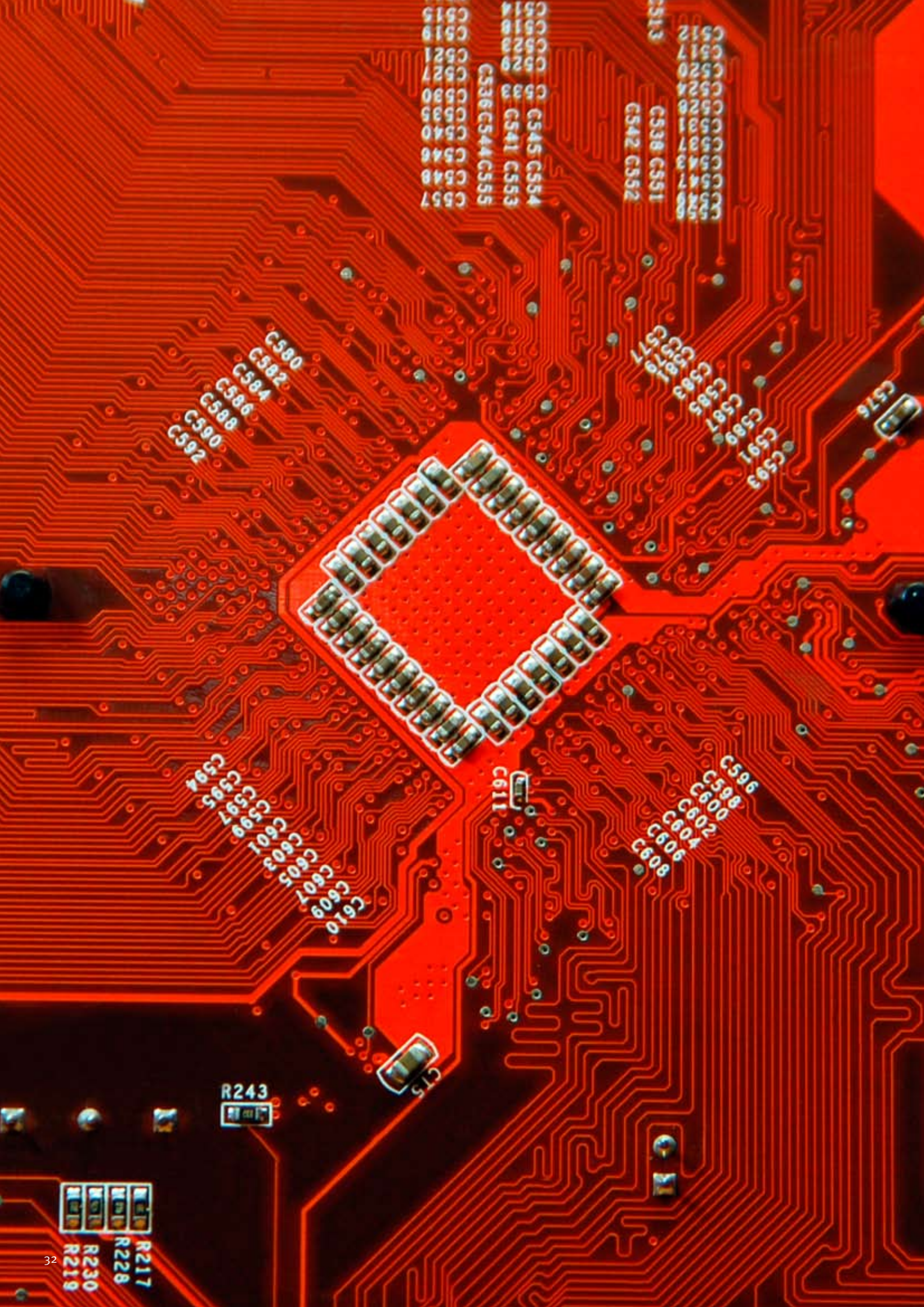
The future? Globalisation will provide new opportunities and markets for plastics. Owing to the low-entry barrier for plastics conversion, however, the labour and resources in this industry may increasingly be located outside Europe. We therefore envisage that the European plastics industry could increasingly focus on research and technology development, rather than production.



Facilitating mobility and communications

Globalisation will lead to increased transportation of goods and increased travel. Plastics, as we have already seen, have an important part to play in minimising fossil fuel consumption, and this role will only increase as globalisation takes effect. In addition, increasing use of e-mail and digital communication will mean that the use of traditional mail will decline, with only people and goods needing to be physically transported.

The future? Plastics will continue to play a key role in the evolution of digital communications, enabling miniaturisation and portability and helping to facilitate the increasingly integrated communication and networking that people demand, while minimising impact on the environment. As more and more plastics are used around the world, the question of how to deal with waste or used plastic will become increasingly important, especially given public concern about issues such as marine litter, biodegradability, and the use of plastic shopping bags. In the coming decades, the plastics industry will need to redouble its efforts to educate the public and counter popular misconceptions about plastic, promoting at the same time the responsible disposal and re-use of plastics, and, especially, increased energy recovery from plastics.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Accelerating technological change

Plastics have come a long way during the past twenty years, and in the light of Ray Hammond's predictions of exponential technological advances, we can expect even more startling developments in the years to come. At present, a lot of future-oriented work is directed towards the following:

- Opening up new possibilities with nanotechnology
- Developing faster, cheaper chips using conductive plastics

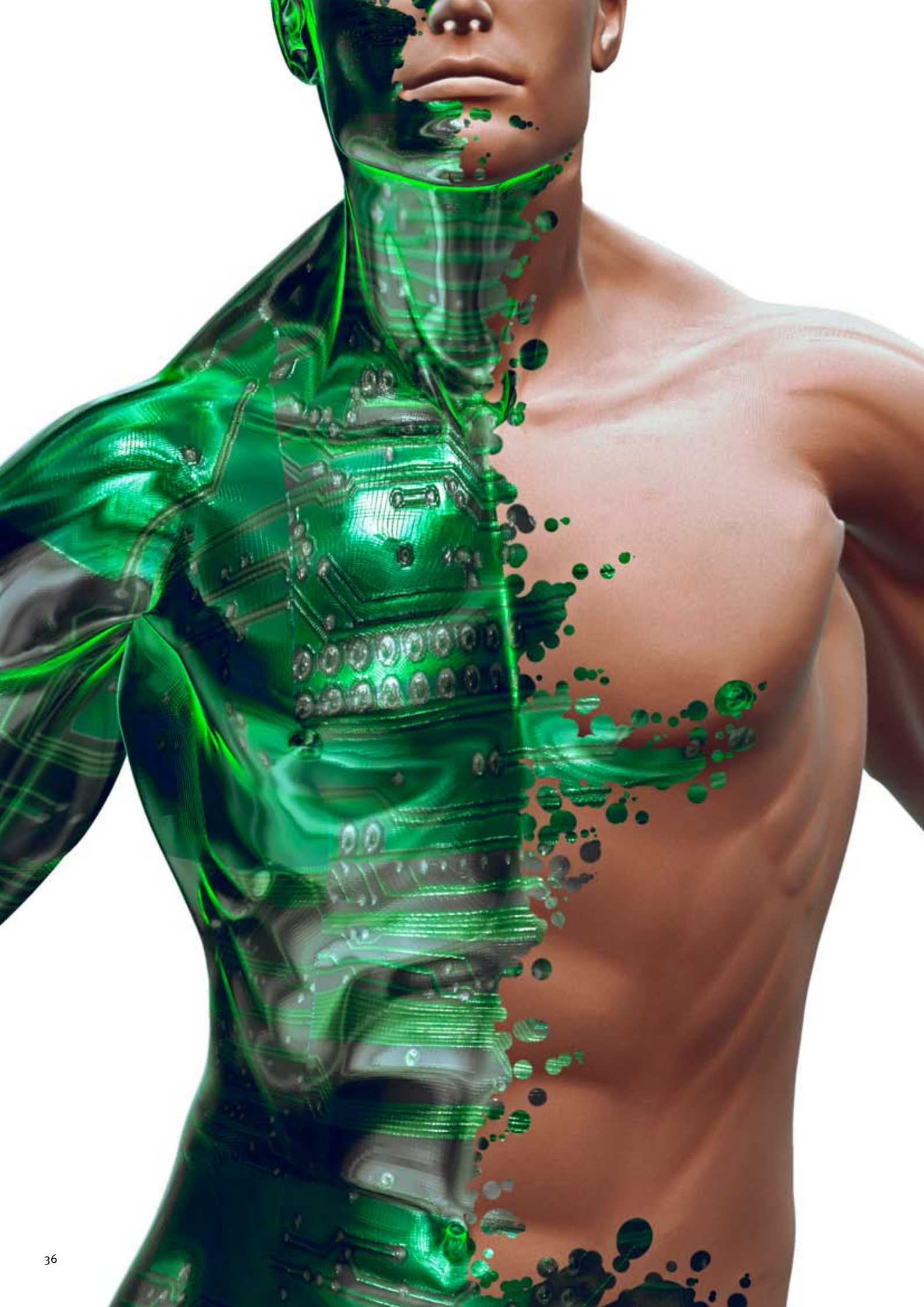
Opening up new possibilities with nanotechnology

Through nanotechnology, it is possible to create special nanocomposites that will be more resistant to heat, scratches, dents and tears. Plastic nanotubes – very thin 'wires' that are not only as conductive as copper, but are extremely flexible, lightweight and durable – are expected to lead to conductive paints and coatings, as well as fibres, giving rise to 'smart' fabrics, for instance. 'Self-healing' polymers will use nanotechnology to identify and repair lesions in structural plastic parts, which will be especially useful in the case of buried structures, such as underground pipes, optical fibre systems and cables.

Developing faster, cheaper chips using conductive plastics

The continuing miniaturisation of circuit boards and components relies on high- performance plastics to provide tough, dimensionally stable parts that can withstand both the stress of assembly and the strain of use. In the future, it will also depend on plastics in the form of conductive polymers (developed using nanotechnology) that can be used to make inexpensive plastic chips that can be easily printed on foil. They will form the basis of tomorrow's shopping experience, for instance, when, as radio-frequency identification tags, they replace bar codes. The thin, flexible and robust capabilities of plastic electronics have a wide range of possible applications – from hospital bracelets that are automatically updated with relevant patient information when a medical file is changed, to packaging that will say if it has reached its expiry date, and flat panels that can project individually addressed advertising. They will be incorporated into many things around us (our clothes, for instance, and continually updateable e-books). And the fact that such chips are cheaper than present silicon chips will cause the price of many consumer electronic devices to fall, making them more widely accessible.

The future? The remarkable advances in the science of plastics, their versatility, wide availability, cost-effectiveness and the high-quality mass production they allow, will increasingly mean that people in the developing world will have access to more sophisticated products, helping to improve their quality of life. The industry will continue to work so that the technologies it creates are sustainable, environmentally sound and socially responsible.



The healthcare revolution

The longer we live, the more we will come to rely on plastics to ensure our health and wellbeing. We already rely heavily on plastics to maintain hygiene by protecting food and drugs from contamination and deterioration and guaranteeing the sterility of medical equipment, containers and suture materials. Surgeons and nursing staff are increasingly using apparel and masks based on plastic fibres, while other plastic items that are widely deployed include radiation- or heat-sterilisable syringes, blood and nutritional bags and tubing systems, inhalers and dispensers. These will all continue to evolve, of course, but two fields in which plastics are currently making important contributions in healthcare are worth examining here in more detail:

- Facilitating diagnosis and treatment
- Making more effective and life-like prostheses

Facilitating diagnosis and treatment

• **Getting natural data more easily.** Patients with heart conditions can wear lightweight plastic ECG equipment for long periods to provide 'ambulatory data', providing doctors with more accurate information on the patient's condition.

• **Safer surgery through plastic robots.** Robots encased in plastic are helping surgeons to take pictures, remove tissue samples or operate inside patients, without the need to perform dangerous invasive conventional surgery.

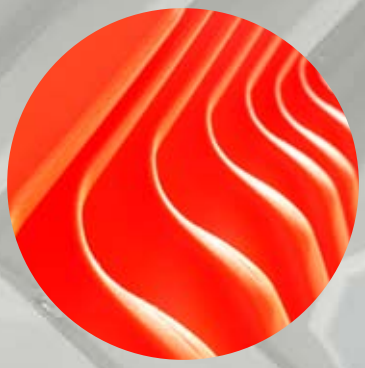
• **Targeting treatment.** Receptacles made from plastics are being used to deliver powerful drugs to sites deep within the body and maintain anti-cancer drugs in blood plasma for longer periods than standard formulations. In the treatment of HIV, carbon nanotubes, made of plastics, have been used to direct HIV-blocking molecules into human cells. Although in the preliminary stages, this development could eventually lead to a new treatment for the virus.

Making effective and life-like prostheses

Plastics are key components of modern prosthetic devices, providing comfort, flexibility, mobility and a life-like appearance. They are ideal for this purpose, as they are safe, hygienic and designed to be biocompatible with the human body.

• **Joints.** Artificial hips and knees use plastics to help provide smoothly working, trouble-free joints.
• **Muscles.** There is also a new generation of electroactive polymers, plastics that move in response to electricity. Named 'artificial muscles', they share the same properties as human muscles: they expand, contract, push and pull under the influence of electrical charges applied to one side of the plastic. Already engineers are developing artificial-muscle-powered devices, including a knee brace that prevents injuries. Tiny pumps that deliver drugs are also constructed from plastics.
• **Organs.** New body parts have been developed, based on plastics, that can restore the functionality of hearts, kidneys, ears and eyes (offering the promise of restored sight to some blind people).
• **Blood.** Artificial plastic blood has been developed that could act as a substitute in emergencies. It could be particularly advantageous in remote areas, as it is light to carry, does not need to be kept cool and can be kept for longer than natural blood.

The future? We believe plastics will be at the forefront of the ‘Prevent-Extend’ revolution predicted by Ray Hammond. We can envisage many areas of healthcare in which plastics could contribute with substantial advances. Magnetic resonance imaging (MRI), for instance, cannot be used in conjunction with metallic surgical tools: as a result, doctors can look at a tumour, but they cannot operate on it under an MRI scanner. This barrier could be overcome by a new plastic robot with no metal or electrical parts. We foresee the use of plastics-based microsystems and nanotechnologies in medicine, with nanopolymers being used as carriers for drugs that directly target damaged cells, and plastic micro-spirals used to combat coronary diseases. Eventually, smart plastics will start to interface directly with our bodies. Scientists are building a new bionic ear coated in smart plastic that boosts the growth of nerve cells in the inner ear when it is charged with electricity. Plastics are also being used in micro-electromechanical systems: these very small plastic devices can be placed on the skin to give instantaneous readings of glucose or lactate levels. Future applications of this technology could include the detection of cancerous cells.



Plastics and everyday life in 2030

As the world around us changes, our lives will be affected both directly and indirectly. Plastics will not just be a tool to respond to the major challenges facing the global community; they will also be an intrinsic part of our everyday lives. The key driver of change here will be the acceleration of technology: the combination of technology and plastics will change the way we live, work and relax.



At home, at work and on the move

In his report, Ray Hammond mentions many developments that will be affecting our lives in 2030. He also mentions that many of these developments will rely heavily on plastics. For instance, the people we meet in the Super Web communities he envisages will become 'real' through the mediation of plastics and nanotechnology. Plastic-encased technologies will be implanted into our bodies, connecting us even more intimately with our artificial support and communications systems, and, through them, with our loved ones and preferred communities – no matter where they may be. Satellite and road-traffic control systems will depend on plastics, and our automated vehicles will be largely (though probably not completely) made from plastics. Similarly, both at work and in the home, a lot of mechanical and routine work will be taken over by robots.

Ensuring health and safety

We have already seen how plastics help to maintain health through hygienic food packaging, and how plastics will play an increasingly vital part in healthcare. But plastics will also have an increasingly significant role to play in keeping people safe from physical injury. Plastics that are not only stronger than steel but also unobtrusive, light and comfortable already form the critical component in protective workwear and equipment across a wide range of industries and occupations, from construction and engineering to law enforcement, the fire service and the military. And, of course, these super-strong plastics protect cyclists and motor-cyclists in traffic, too. People naturally want maximum protection with minimum discomfort, and as plastics become tougher, lighter and more flexible, we will undoubtedly find new ways such plastics can contribute to people's safety.

The future? Health and safety in the broadest sense will inevitably be strong concerns of people in all parts of the world in the coming years. As an industry, we already do a great deal in this regard, and are committed to ensuring that the production of plastic products fulfils or sets the highest safety standards. But we are confident that the industry will continue to devise innovative ways in which plastics can help to raise health and safety standards quickly, affordably and sustainably for those at most risk – not only in advanced markets, but also in poorer regions, air-polluted mega-cities, conflict zones, refugee camps, or remote areas.

Leisure and sports

Plastics will continue to play an important part in sports and leisure activities, too. They have already revolutionised the sports industry, with innovations like clothing made from elastane fibres, which provide a better fit and stretch, in line with the athletes' movements, and hollow microfibres, which allow the sweat to be transported away from the body. Plastics have also brought us lighter, stronger equipment, such as racquets and surfboards made from graphite and polyurethane.

The future? In the future, we can expect to see self-monitoring devices that can register an athlete's physiological condition and detect any medical abnormalities (e.g., due to substance abuse). We will see playing surfaces that adapt to climatic conditions, absorbing heat, controlling moisture, storing energy and reflecting light, as well as being textured for the intensity of the sport (junior, amateur or professional), and absorbing impact to reduce injuries. They will also monitor players' positions, and individual items like tennis balls will themselves signal when 'the ball is out'. In the case of endurance sports or expeditions, we will see tracking devices that will relay the wearer's medical condition and precise position. In a different approach to sports, we may also see the development of textiles and devices to make participation in sports easier and more attractive for people who would otherwise lead a completely sedentary life, with increased health risks.

Plastics*Europe*
November 2007

PlasticsEurope is one of the leading European trade associations with centres in Brussels, Frankfurt, London, Madrid, Milan and Paris. We are networking with European and national plastics associations and have more than 100 member companies, producing over 90% of all polymers across the EU27 member states plus Norway, Switzerland, Croatia and Turkey.

The European plastics industry makes a significant contribution to the welfare in Europe by enabling innovation, creating quality of life to citizens and facilitating resource efficiency and climate protection. More than 1.6 million people are working in about 50.000 companies (mainly small and medium sized companies in the converting sector) to create a turnover in excess of 280 billion € per year.
The plastics industry includes polymer producers - represented by PlasticsEurope, converters - represented by EuPC and machine manufacturers - represented by EUROMAP.
For further info see the web links:
www.plasticseurope.org
www.plasticsconverters.eu
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