Universal Display

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Sustainability: 'Green Mannequins'

by Jonathan Berlin

The family of plastics remains a favoured material in the manufacturing of mannequins- it can last for years, it's easy to mould into form, and it has a cheap cost in comparison to other materials. With over 2.5 million of mannequins in UK retailer stores, the vast majority are made using fiberglass, making it the most ubiquitous form.

These polymers currently being used within the manufacturing industry are virtually all derived from oil, non-biodegradable, and difficult or harmful to recycle or reuse due to their complex composites. Whilst the industrial method for obtaining these monomers hasn't changed much over the last 60 years, through the fractional distillation of crude oil, the situation has. There are increasing environmental pressures to find new ways of making plastic if we want to continue to use them.

We are becoming more aware of this problem. We only have to look at the 'Garbage Patch' covering over a million square miles of the Pacific Ocean with plastic waste too tough for bacteria to break down, and odd fragments of plastic ('mermaid tears') that continue to wash up on shore. This island of plastic debris highlights the seriousness of our dilemma.

Being environmentally conscious is not a fad, as more companies move away from these plastics in a 'post-petroleum' world, in favour of bio-based or biodegradable alternatives. Whilst bioplastics remain a minority and currently only represent 1% of the total plastics market today, this is projected to grow continually (15% increase from 2013 to 2016 alone).

At Universal Display we pride ourselves in being forward thinking, and the environmental repercussions of our production lay at the forefront of our business decisions, which is why we are championing this cause.

PLASTIC WASTE

The Garbage Patch in the Pacific Ocean is made up of plastic waste, and is the same size as Hawaii.

What is currently available on the market?

What are the pro's and con's?

- Bamboo finish
- Polypropylene (PET)
- Medium Density Polyethylene (MDPE)
- Polystyrene (PS)
- Paper
- Metal
- Fibreglass

Bamboo finish

For the environmentally conscious like ourselves, we have recently introduced a new way to manufacture mannequins.

By combining Bio resin & natural Bamboo fibres, any Universal Display Mannequin can be specified in Bamboo finish.

All our products can also be sprayed with a water based paint. The use of Bamboo reduces CO2 emissions significantly. Combined with water-based paint, a bamboo mannequin reduces CO2 emissions significantly. All these positives changes in the process come without drawbacks as the structure and finish quality on a bamboo mannequin is identical to its fibreglass counterparts.

Fibreglass

Fibreglass is currently the most widely used material for the manufacturing of mannequins, with a balanced ratio of weight and sturdiness. A lighter and stronger product results in lower costs for shipping and storage. Given that it can be moulded into almost anything to meet most specifications, with few constrains on size, shape, colour and finish, this has given designers unlimited possibilities and creative freedom that metal and other materials cannot. This material can also be affixed with balls and joints—enabling the model to look even more realistic. This composite can therefore deliver great styling and appearance, whilst also being cost effective. Paints need not be cellulose, in fact water based paint is a perfect substitute. This can be easily painted over and be changed to look different when necessary.

As we all know,it is not recyclable and the chemicals used in its production are not overly kind to the environment. The problem with fiberglass lies with the manufacturers of the raw materials, who are not willing to make changes and bring in substitute materials in place of those traditional ones. Pressure from other industries such as boat and home builders will in time bring these new materials to the smaller industries such as ours, but it is difficult to put a time scale on this. All we can do is be more careful in our practices and means of manufacture, thus using less material, reducing pollution from extracted fibreglass dusts and resins and using water based paints.

Since fibreglass is a very sensitive material and cannot withstand shock or fall, this material is disadvantageous in that is requires extra care in its handling. That being said, with the proper care fibreglass structures provide an exceedingly good life span. It can also be easily painted over and changed into different looks where necessary, making it a cost effective way to replace and repair parts.

DESIGN FREEDOM

Given that it can be moulded into almost anything to meet most specifications, with few constrains on size, shape, colour and finish, fibreglass has given designers unlimited possibilities and creative freedom.

Plastic

Plastics – PET, MDPE and PS are all viable materials to use in the manufacture of mannequins and forms. The versatility of plastic is an obvious advantage, which is well suited to the requirements of mannequins. The low melting point and high malleability in comparison to other materials, means it can be formed into basic and complex shapes, poses and finishing textures with relative ease. Plastic possesses great structural strength, a much needed quality for mannequins to stand freely. By changing components of the structure, you can control properties of the final product making one of the most versatile materials available today. All of these qualities enable mannequins to better emulate the appearance of a real person with realistic facial and body features.

91%

of plastic still isn't recycled.

Its durable nature means it can offer a longer shelf life (up to 6 times longer) than other materials and withstand the rigours of shipping. In terms of convenience, it's also less expensive.
From a business and consumer point of view this is of benefit as orders can be completed in less time, with a faster moulding process, and thereby delivered at a cheaper price.

In terms of the visual impact – plastics are of course a forerunner. It is easy to produce a well made, strong, durable and good looking product. The set up costs are high but the unit cost is lower than other products in a run scenario as the production is mechanised and the product needs very little attention once removed from the moulds. Packaging can be greatly reduced also as the product does not need to be as well protected as other materials when being distributed.

These plastics are recyclable, but this has a number of problems. Due to their long molecular structure, they are too large and too tightly bonded to be broken apart with ease, which is a problem given the disposable nature in which we consume plastics. The main problem being that there are various polymer types and they must be recycled separately and at this time there is no way of doing this mechanically. Therefore, most sorting is done manually into type and colour which is expensive and time consuming. Products with different colours and different types of plastic mixed together are very difficult to recycle. There is an argument that in these cases, the energy and resources used in the recycling process exceed that required to make new plastic. PET is the most efficiently recycled material and is 100% recyclable. About three quarters of reclaimed PET is used to make fibres for carpets, fibrefill, apparel and goetextiles. The remainder is typically extruded into sheet for thermo-forming, stretch blow-moulded into containers or compounded for moulding applications.

According to Natural Geographic (2017) 91% of plastic still isn't recycled. By 2015 humans had produced 6.3 billion metric tones of plastic waste, only 9% of that was recycled, and 79% was discarded in landfills, set to increase 12 billion metric tons of public wastes to end up in landfills or the natural environment by 2050. To tackle this, a global approach is needed to rethink product design and recycling strategies.

Alternative to landfill, due to the calorific value of plastic, is incineration for energy recovery. As plastic is an oil based substance, this pollutes the atmosphere with carbon dioxide, contributing to climate change. The chemicals used in its production are then released again in its incineration.

The largest issue is that in the manufacture of these materials 8% of the world's oil is used, harmful solid wastes are produced as well as carbon dioxide, nitrogen oxide and sulphur dioxide emissions. Coupled with the fact that certain chemicals used in the manufacture of the raw material are thought to be hazard toxins.

Finally, it appears that plastics are virtually non-biodegradable. Therefore, unless incinerated or recycled they could be around for many hundreds of years. Polymer compounds can survive for many centuries before nature is able to degrade it, anywhere between 400-1000 years before degrading. Meanwhile they continue to clog our waterways, forests and other natural habitats. This is only an estimate given that plastic is a relatively new invention.

PACKAGING

We have already implemented an environmentally friendly means of packaging, reducing 70% of the bubble wrap and foam used when packing our good. However, whilst we have the need to reduce the impact on the environment, there is not an adequate replacement for some of the packaging materials used that are essential in delivering a great quality product produced in this material.

Paper

Most virgin (un-recycled) paper is made from wood grown in 'sustainable forests'. However, we propose manufacture from recycled paper, such as grey board and Kraft paper, even newspaper. Recycling is thought to be cost and energy efficient and emissions are virtually none. As this is low grade paper it can be recycled back to egg cartons, insulation or animal bedding. Although about a third of all material will end up as sludge. This being a solid waste comprising of small fibres, glue, etc that has been filtered during the recycling process. Traditionally this waste has been consigned to the landfill. However, new alternatives are currently being explored, including composting, incineration and recycling in the form of gravel and concrete.

Again, we can produce with metal or plastic arm, wrist, and waist, etc fittings which can be reused or recycled. Base plates can be made from metal which again can be reused or recycled. We can also spray in water based paint and cover in fair trade cottons and fabrics. Post industrial textile waste can be recycled by either shredding into fibres and then mixing with virgin fibre to create a new fibre, or if a lower grade is being used as wipes, stuffing for cushions, carpet underlay or mattress padding. We would use chipboard or similar platters which are already recycled and thereafter can be further recycled by turning into mulch, pet bedding and fuel for timber fired boilers. If new timber is sourced for whatever reason we would be sure to use wood which has been originated via the FSC or shows their logo (Forest Stewardship Council).

I feel that this type of product is a real forerunner as not only is it the best product in terms of raw material, it's manufacture is non polluting as it is a hand made item and we can manufacture in developing countries such as the Philippines which will support communities and give financial assistance to a struggling economy. We have an option of UK manufacture also which removes the need for shipping and concerns that may come with this. Further to this there is an alternative for paper pulp product, although not a used, tried or tested application for this industry it is completely possible. That said, the end product may not be of the highest standard and may look very 'raw'. Again packaging requirements can be decreased and less unfriendly products can be used to cushion such product in transit.

In terms of visual effect – we can produce a high quality, well developed product at a reasonable price We can, obviously add a fabric covering, giving the result of a high end product which automatically says 'environmentally friendly' without having a product that looks as if it has been made using such materials, i.e. raw.

Visually, a high quality product can be produced at a reasonable price. In comparison to the more popular materials, plastic and fibreglass, this may not execute the same detail, juxtaposing from their elegant and feminine poses.

Overall, paper is the greenest option, using less energy and producing lower carbon emissions then other sourced materials. The process of creating recycled paper uses 31% less energy* than the creation of virgin fibre paper. With advances in technology and processes, recycled paper can now replicate the same performance as non recycled paper. Research and innovation in the recycled paper industry now means that printing on recycled paper does not mean approaching the design or printing process in a different way.

Metal (Steel)

This a ferrous metal and the most recycled material in the world. Or alternatively aluminium a non-ferrous metal. The obvious problem with metal is that it is mined and all types of mining have a devastating effect on the environment. Steel mining leaves scars on the landscape and surface mining used to extract aluminium employs vast quantities of poisonous chemicals which leak into the ground and contaminate the earth and water for miles around.

The big pro is that metals are 100% recyclable, i.e. they can be recycled without losing any of their properties. In fact at least 25% of all metal product that you may buy is made from recycled steel. Recycling is easy due to its magnetic qualities making it easy to sort, melt down and reuse. The technology in place for processing scrap is extremely advanced and thus uses fewer resources than recycling of other materials.

Aluminium however is not good for the environment due to its intense mining and the tons of red mud (a caustic brew of chemicals) left after its extraction. It also takes huge amounts of electricity to smelt it.

In terms of visual impact – metal if used correctly can look sharp and stunning. We can produce wire forms both in the UK and Far East, which if designed well could work well. We manufacture for many brands currently types of draping stands which work in conjunction with paper forms or hangers, which again are well designed and visually pleasing as well as functional. We can also cast in metal – which we currently do in production of certain bases, for example a workroom base. We can and could cast a form, albeit, its weigh may be problematic but for smaller items such as accessory pieces it is a very viable means of manufacture.

THE RECYCLABILITY OF METAL

Metal can be recycled without losing any of its properties.

New Alternatives

The future of manufacturing.

Bamboo Fibre as Reinforced Polymer Composites

As we begin to respond to the increased demand for biodegradable, sustainable and recyclable materials, bamboo has been shown to have properties that lend itself well to extreme high-temperature cooling processes. This makes it an ideal fibre in the production of plastic substitutes.

Currently, this has caught on in industrial engineering communities in China. For example, Yixing Hengda Bamboo Grid are todays market leaders of bamboo grids used in high temperature cooling processes in heavy industry. The company has found its performance in extreme high temperature situations to have surpassed that of plastic (with a product lifetime of 15 years, three times that of PVC), and shows a similar longevity. Dubbed the 'Green Steel' of the 21st century, The 2015 World Architecture Festival predict that bamboo will 'revolutionise the building industry', and go forward to replace steel as the dominant reinforcing material.

Fibres from bamboo can be extracted and mixed with organic resin to create a mouldable material that can be pressed into any shape under certain pressure. With a tensile capacity that exceeds that of steel, it is also a quarter of the weight. The durability of bamboo fibre composites mean it is now being considered for other industrial applications, such as car parts in the automotive industry, panelling and disaster relief construction projects. It's believed bamboo fibres will be capable of being used to build sky scrapers in the near future.

Furthermore, there are superior environmental aspects. Bamboo is sourced from sustainable rain forests, and can be fully recycled back into nature at the end of its product lifetime.

Bamboo grows naturally in diverse climates, predominantly in Asia and South America in abundance. With a high growth rate of up to 35 inches a day, they are the fastest growing woody plant in the world. Unlike traditional forestry operations where the trees are fully harvested or replanted, bamboo is regularly trimmed. Grass roots remain stabilised in soil whilst new shoots are generated, providing a continuous supply of material for the industry.

At the end of the products lifetime, bamboo fibres can be returned to the ecosystem, fully recycled back into nature, as organic waste or fertilisers.

It's believed as the environmental benefits of bamboo industrial products, and its tensile strength become more well known, the utilisation of bamboo fibres will be revolutionised and gain more traction.

BAMBOO FIBRES

Certain types of bamboo can grow as much as 35 inches a day, making it a resource we have in abundance. Bamboo fibres show more tensile strength than steel.

Recycling of Fibreglass Now a Reality

Industries have long been seeking the answer of how to dispose of fibreglass in an environmentally conscious way. The major component of glass fibres and resins used in the manufacturing of fibreglass happen to be valuable raw materials required for the kiln-firing of cement. Fiberline Composites, from Denmark, signed a contract with German Zajons who specialise in converting fibreglass waste into alternative fuels for the industry, and Holcim, who is a subsidiary of the worlds leading cement manufacturer. This contract was the first of its kind, taking a 'zero landfill, zero energy' approach.

This enables excess fibreglass that has reached the end of its product lifecycle, to be used as a key component in the making of cement. The production of cement is dependent on large quantities of sand, which is the main constituent of glass. Holcim utilise both the energy as well as the minerals in the fibreglass, and thereby saves on fossil fuels and raw materials. The additional polyester found in fibreglass when resins are heated can be used as an energy source to propel internal electric turbines in the cement production. The cement can then be used in the building of roads, schools, hospitals, housing and dams as well as decorative applications. Global Fiberglass Solutions, who are looking to build and manage facilities to collect and recycle fibreglass across the UK, have developed applications such as railway sleepers.

While this does remain a relatively untapped waste resource, it is hoped that the next step would be to set up a formalised collection scheme on a global scale. There is hope that this will increase in its commercial activity and thereby reduce the cost of this process.

This takes a circular economy approach, and guarantees a 100% of all glass reinforced plastic will be used up. This will enable mannequins to continue to be manufactured using fibreglass, without the environmental impact.

Liquid Wood

As paper manufacturing companies are made more aware of the environmental impact of importing wood, they are looking for new uses for parts not incorporated in the production of paper, using liquid wood to make their case.

This biopolymer is derived from pulp- based lignin, sourced as a residue from paper mills. To transform this into the structure of a plastic, lignin is combined with nothing more than water at an extreme temperature and pressure is applied. In doing this, you have a composite substance flexible enough to form into any shape, whilst also possessing a durable quality. According to manufacturers this bioplastic, referred to as Arboform, can be mixed with hemp, flex or wood fibres alongside other additives where petroleum based plastic is currently being used. Whilst relatively new to the market, German researchers have already succeeded in using the composite in the product of children's toys, hi-fi speaker boxes, car parts, 'eco pump' shoes, and golf tees.

Liquid wood is set for a promising future within the industry, due to the fact its produced using wood by-products, making it both biodegradable and easily recyclable.

This is a win-win according to researchers from Fraunhofer Institute for Chemical Technology, who assert that this combines the high stability of wood, with the injection-molded capabilities of plastic. Under the right conditions, this material can behave like melted plastic and possess its precision, flexibility and durability, suitable to mould into a range of different forms. The bio-plastic looks and feels like wood but its ability to change shape lends much greater design possibilities. This is revolutionary, bringing together two of the most powerful materials used.

LIGNIN WOOD

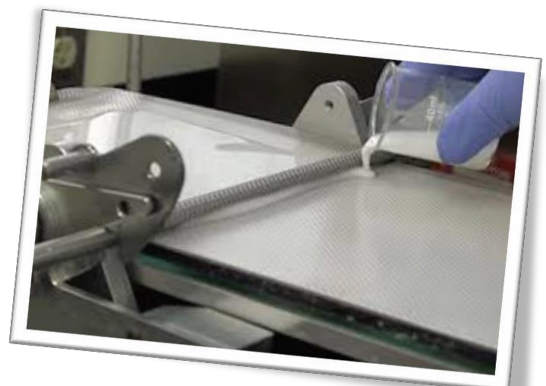
This combines the high stability of wood, with the injection-molded capabilities of plastic

Currently, the pulp industry produces in excess of 130 million pounds of lignin a year, making it widely available and with sustainable potential. Furthermore, 30% less energy is required in its production because the temperature profile is significantly lower compares to conventional plastics.

Liquid wood has immense environmental potential as Arboform only releases quantities similar to that of wood (carbon dioxide and water), that plants have found from the atmosphere during their growth. Once broken down into small pieces and re-processed 10 times, no change in the material properties was detected, making it recyclable.

In consideration of these credentials, this would be suitable in the production of mannequins because after treatement, it can be sawed, planed, patined, drilled, carved, nailed or glued. Though still within the development stage, it may well replace plastics in the near future.

Milk Protein



Once used to make buttons, adhesives, and a jewellery substitute, researchers have revitalised the idea of using casein, a protein found in milk, to make biodregadable material. These polymer chains of casein have been shown to mould plastic to rival the stiffness and compressibility of polystyrene.

Whilst this protein isn't a new discovery, previously, researchers found this protein to be too fragile and dissolve in water. Casein is now blended with a small amount of silicate clay and reactive molecule glyceraldehyde to prevent cracking. Once freeze-dried and cure in the oven, this has the potential to be used in furniture cushions, insulation, edible packaging and other commercial products.

The best part about this, is that the plastic has been shown to break down by as much as 33% with 30 days of being in a landfill, making it completely biodegradable. Despite this, there are implications on the dairy industry. With water consumption, water pollution, and the greenhouse emissions produced by cows, this contributes to a significant environmental footprint. In this respect, this is merely shifting the environmental burden from being fossil fuel based, to other areas.

Poultry Feathers

Technology has advanced in such a way that can transform poultry feathers into a thermoplastic, what might seem at first to be an unlikely plastic substitute. These feathers are composed almost entirely of keratin, a protein that is responsible for the strength found in hair, wool, fingernails, hooves and horns.

First, the feathers are cleaned and pulverised into a fine dust powder. Once processed with a chemical methyl acrylate they undergo polymerization, which results in films that have been termed 'feather-g-poly (methyl acrylate)'. This protein offers the strength, durability and tear-resistance of plastic that other agricultural sources including plant proteins and modified starch, cannot. This has proved to have tensile strength better than that of wood whilst still exhibiting flexibility, and offer values similar to that of polypropylene.

One of its selling points is that the main resource required is a by-product of the meat industry, and therefore readily available inexpensively and in abundance (with an estimated excess of 3 billion pounds of chicken feathers plucked each year in the United States alone).

Besides making use of feather which would have otherwise ended up occupying space in landfill sites, it is anticipated that this resource is fully biodegradable. As there are no archeological sites containing reservoirs of feather, this would lead us to believe that feathers break down over time. In addition to this, unlike most other thermoplastics, this is an attractive alternative as it doesn't depend on any fossil fuels, making this one of the most eco-friendly plastic substitutes.

PACKAGING

These avenues we have researched not only apply to the production of our mannequins, but also how we intend to package our mannequins in transportation.

Biodegradable Plastics

Biodegradable alternative to conventional plastics.

The process of extracting starch.

An example of what intensive agriculture can do to land.

FAST FACTS

70%

According to NatureWorks PLA produces almost 70% less greenhouse gases when it degrades in landfills.

65%

PLA uses 65 percent less energy during the manufacturing process than creating a similar polymer from raw petroleum.

Biopolymers are designed to look, feel and act like petroleum based plastic, with the exception that they are biodegradable. Here are a few of the ones having success at the moment:

Bioplastics

Bioplastics are those derived from renewable biomass sources, such as vegetable fats, corn starch and microbiota. In the US this sugar comes from corn, and in other countries can be extracted from sugar cane, sugar beets, wheat, and potatoes.

Polyactic Acid (PLA)

This is currently one of the most promising plastic alternatives on the market. Also known as polylactide, and commonly referred to as PLA. Corn, for example, undergoes a mechanical process in order to separate the starch from the kernel ('wet milling'). The starch is then heated with enzymes or acid to hydrolyse the starch to dextrose, in either crystalline or liquid form.

Through fermentation, the dexrtrose is converted to lactic acid, and during the process of polymerisation these molecules link up into long chains which bond together to form PLA. This is turned into sheets of flat plastic or pellets, which can then be moulded into a variety of different forms including containers, films and fibres.

The properties of PLA are similar to those of PET, and is already being done on an industrial scale at manufacturing plant Natureworks in Minnesota. PLA's are reported to only just beginning to live up to their potential. Their increasing popularity has seen its expansion from primarily food packaging to encompass a wide range of fields including medical, textile, cosmetic, automotive and household applications, and can now make virtually any product that would normally be made of plastic. Scientists are now trying to make PLA even stronger and more heat-resistant which will open up new avenues for the plastic, including automotive parts.

The benefit of using these polymers is their ability to fully biodegrade within a span of 47 days under industrial composting conditions. They also do not let off toxic fumes when they burn. What's more, when burned and manufactured, they use up to 50% less fossil fuels that petroleum-based plastics.

Considerations

These methods require energy intensive recycling methods. Not all countries are set up for bioplastics with access to specific industrial composter facilities needed to break down bioplastics. If placed in regular compost bins it will behave just like a regular petro-plastic.

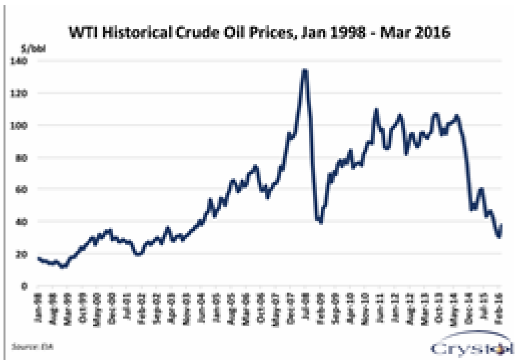
Arguably, how green are these alternatives? Increasing our reliance on plastics sourced from crops such as sugarcane inadvertently introduces new environmental concerns. Plant-based plastics rely on intensive agriculture of the corn and other forms to be used in manufacturing, and there are environmental costs associated with this.

These starches are water intensive crops, and there is only so much land that can offer this water to grow sugarcane all year round. With the demand for PLA increasing, this will likely cause more stress to these areas in places like Brazil and India. Over time, as more soil is used this will be troublesome for the land, making following seasons less predictable. This method is therefore reliant on people having enough land to grow food stock to keep up production, and therefore isn't prepared to be up-scaled. Agricultural residue management will be a vital strategy in overcoming this.

One possible way around this would be to use CO_2 feedstock instead, something which is being researched at the moment. Once the right materials are found, more than 90% of today's plastics could one day become bioplastics.

Viability: Fit for Purpose and Fit for the Environment

The Cost of Oil



The chart above shows the fluctuation in oil prices from 1998 until March last year.

1%

Bio-based polymers comprise less than one percent of the total global polymer market.

PRICE OF BIOPLASTICS

Bioplastics are subject to changes in the polymer industry. As such, when oil prices decline, this means manufacturers of oil-based plastics enjoy raw material costs at a lower rate.

The usefulness of any substitute depends on the cost and versatility of the end product. The costs of bioplastic polymers are generally still much higher than that of their traditional plastic counterparts. As of yet, the bioplastic industry has not been able to create polymers that are attractive in terms of price, persuasive enough to make people willing to change their current processes. This, in part, is why bio-based polymers comprise less than one percent of the total global polymer market.

Overall, from a price standpoint, biopolymers can be anywhere between 2.5-7.5 times more expensive than traditional petroleum based plastics.

Unfortunately, these innovative ways to manufacture plastic substitutes are subject to changes in the polymer industry. As such, when oil prices decline, this means manufacturers of oil-based plastics enjoy raw material costs at a lower rate. This is then delivered to consumers at a lower price for their goods. This raises the question whether the market demand for environmentally friendly products outweighs the relative higher cost? This would likely impact companies decisions to look for viable alternatives to oil based products. In this sense, the 'take off' of plastic alternatives is dependent on the fluctuation of oil price.

Having said that, it is likely that as technology for producing these improves, and more manufactures turn to eco-friendly plastic alternatives, the unit cost to produce will be bought down for the end consumer. With time, it is hoped that this will drive investment and lead to even more applications through customer demand. This will lower the costs regardless of the associated oil prices at the time.

We have proven above that there is the capacity to fill the worlds plastic needs from polymers not derived from petroleum, but this rests upon required change. To do this, governmental support has been suggested as a way to regulate the cost of oil, so that oil-based plastic will lose its appeal in terms of value for money.

Short of government enforcing law to place a fixed price on oil, the bioplastic and fiber composite industry will need to come up with a way to compete with conventional plastics, otherwise they will never be more than a niche alternative. When looking at the upsurge in solar power, global warming initiative, plastic bag bans and other eco-friendly innovations, this isn't unbelievable. For instance, ten years ago solar power account for less than 0.1% of electric generated in the US. Following this, the price of photovoltaic modules dropped by $3.50 per watt, enabling it to become the fastest growing source of electricity in the country.

Despite this, widespread use has been achieved over recent years, and with a combination of cost and performance improvements, increasing oil prices, and an increased awareness of environmental impacts will hope to increase their potential and market opportunity.

Furthermore, with most of the alternative plastics, more tests and research are necessary on a grander scale to establish the materials potential and the feasibility of implementation. This is largely reliant on producing larger amounts of composites, and testing its functionality within different products. Only then will we be able to gage the performance in terms of economics, carbon footprint and so on. In transforming these small scale alternatives to mass production at large scale, there is still a lot of work to be done.

Points to consider

- These alternatives offer both the appearance and functionality of the traditional plastic, whilst eradicating the harmful environmental impact associated with petroleum-based plastics.
- Unfortunately, despite small scale successes, they represent only a small percentage of the industry overall. Currently, these are only well suited for companies and consumers prepared to pay a premium price for sustainable products.
- Pioneers of this research note that using current waste or natural materials we can source in abundance as an alternative source for materials is one of the best ways to take a more sustainable approach, and becoming a more environmentally responsible society.
- Much of these composites, or recycling systems in the case of fiberglass, are very much still in their infancy. However, if we were to consider the speed of the development of conventional plastics over the last century, any one or number of these could make a breakthrough in the way plastic is manufactured. In turn this will reduce our global consumption of fossil fuels.