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Improving composites with 'wonder material'

FEATURE

Liz Nickels

Liz Nickels looks at current research into the use of 'wonder material' graphene to improve fiber reinforced plastics.

Graphene is a material made from a single layer of carbon atoms, first discovered during experiments by Professors Kostya Novoselov and Andrew Geim, who were awarded the Nobel Prize for Physics in 2010. For many, it really is a wonder material – over 200 times stronger than steel, the material can conduct electricity even better than copper and is said to has the highest thermal conductivity known to man. One of graphene's most exciting properties is its remarkable thinness – at just one atom thick, graphene is one million times thinner than the diameter of a human hair. While innovative uses for the new material have been found in all kinds of industries, it is no wonder that its strength and lightweight qualities have led researchers to seek out ways in which it can improve the properties of fiber – particularly carbon fiber – reinforced plastics.

In 2013, the European Commission (EC) invested €1 billion as part of a new project entitled 'Graphene Flagship', which, over 10 years, aims to develop graphene-related technologies from use in academic laboratories to applications in a range of industries. The core consortium currently consists of 142 academic and industrial research groups in 23 countries.

One of the projects looking for EU funding was set up by the University of Sunderland in 2014, with the aim to develop lighter, stronger, more energy-efficient, and safe vehicles using graphene, to 'potentially revolutionize the global automotive industry', according to a press release.

Dimensional stability

The university, working with a consortium of five research partners from Italy, Spain and Germany, was selected as a partner for the iGCAuto proposal. The project focused on analyzing the properties of new graphene-based polymer material to determine how it behaves when used to improve the advanced composite materials used in the production of cars, particular with regard to strength, dimensional stability, and durability.

Professor Ahmed Elmarakbi, a professor of automotive engineering at the University of Sunderland's department of computing, engineering and technology, initiated the idea. 'Graphene has tremendous applications for the automotive industry and using it to enhance the composite materials in cars has so much potential,' he said. 'The global automotive industry is currently facing great challenges, such as CO_2 emissions and safety issues.

'The project will investigate using graphene-based materials in the fabrication of nanocomposites with different polymer matrices. This material will provide benefits such as improved strength, dimensional stability and better thermal behavior, better flame behavior (active as flame retardant and for reducing the emission of smoke), and superior durability,' Professor Elmarakbi added. 'There will be challenges with this project; the issue is not only producing graphene-based products, the issue is applying them on a large-scale in cars.'

Composite aircraft

More recently, in January 2016, the Masdar Institute of Science and Technology, based in Abu Dhabi, UAE, and the University of Manchester in the UK launched a collaborative research program covering three projects featuring graphene and 2D materials (Fig. 1).

One of those projects will cover the development of low-density graphene-based nanocomposite foams for engineering applications that include energy. The program will also look at a graphene-based composite aircraft wing could drastically decrease weight; reduce the detrimental effects of lightning strike damage and increase fuel efficiency and range. Graphene-based composites in major components could soon be used in industries such as construction, transport or aerospace, according to the University of Manchester. Graphene-based composites and coatings could

0034-3617/© 2016 Published by Elsevier Ltd. http://dx.doi.org/10.1016/j.repl.2016.06.004

Please cite this article in press as: L. Nickels, Reinf. Plast. (2016), http://dx.doi.org/10.1016/j.repl.2016.06.004

FIGURE 1

In January 2016, the Masdar Institute of Science and Technology and the University of Manchester in the UK launched a research program covering projects featuring graphene and 2D materials.

also improve sports equipment in skiing, cycling, and even Formula 1 in the near future, it said.

'Graphene has huge potential for applications in a large range of sectors, and we are delighted to be collaborating with The Masdar Institute of Science and Technology on these important areas of research,' said James Baker, graphene business director, The University of Manchester. 'The University of Manchester has more than 235 researchers working on graphene and 2D materials and many will now have the opportunity to further their research by working with Masdar.'

Impact resistance

Haydale Composite Solutions (HCS), based in the UK, has been making use of graphene to improve the performance of carbon fiber composites.

Recently, HCS launched three new graphene enhanced carbon fiber prepregs in collaboration with SHD Composite Materials Ltd using epoxy resins from Huntsman Advanced Materials. The products include a structural component carbon fiber prepreg, a prototype out-of-autoclave curing carbon fiber tooling prepreg capable for composite part production in autoclave processing, and a higher operating temperature prepreg for accurate tooling.

The company wanted to increase the impact resistance and compression after impact performance of carbon fiber reinforced epoxy components, by adding graphene nanomaterials. This could enable designers to develop lighter and more efficient carbon fiber reinforced epoxy structures where impact is the principal design consideration, it says. Applications for this new prepreg include aerospace, automotive and sports goods such as bike frames, fishing rods and racing boats.

The higher operating temperature prepreg could also help produce tooling systems with increased thermal conductivity, reduced spring-back and improved accuracy, improved surface finish and hardness, better impact resistance and finally increased resistance to micro-cracking through life over currently available prepreg materials, Haydale reports.

The new graphene enhanced prepreg materials are currently going through evaluation and are available as prototype products to interested companies for their particular areas of application.

'This has the potential to be a real game changer for the composites industry,' said HCS commercial director Nigel Finney. 'We are very excited about the significant improvements in thermal and mechanical performance of graphene enhanced carbon epoxy prepreg structures and look forward to further developing a novel generation of carbon fiber epoxy prepreg materials. We believe we are on the verge of a whole new range of graphene based polymer nanocomposites with some exciting and unique properties, which we believe will be of significant interest to the composite market always looking for enhanced performance.'

Chemical performance

The company is also working with several leading resin companies and also working with a number of end-users including Alex Thomson Racing, creator of the 60 ft carbon fiber reinforced HUGO BOSS racing yacht and Briggs Automotive on the Mono supercar (Fig. 2), to develop use of the material in composites. According to Gerry Boyce, managing director, the graphene can be mixed with either glass or carbon, depending on the application. 'Once we've added graphene into the resin we can characterize what performance enhancements the resin achieves, and because we're composite engineers we understand the influence a new graphene-enhanced resin would have on the overall composite,' he told *Reinforced Plastics*. 'However, while we can see some quite major increases in the mechanical performance of the resin, once you add it to the carbon fiber these increases aren't so apparent. They are, however, still significant enough to make a big difference to composite engineers.'

For example, the company has seen a 50% increase in compression after impact, which is one of the main design criteria for aircraft structures. This means that it could be possible to make graphene-enhanced structures even thinner and lighter and lower cost structures.

One of the programs Haydale is working on addresses the problem of lightning strike (Fig. 3). 'In this application by adopting use of our graphene composites we are looking to make the fuselage material more conductive and avoid the need for copper mesh,' explains Gerry. 'Having developed more conductive resins, we could maybe adapt those materials into the internal structure of the aircraft, such as computer housings and cabin structures which don't require the copious amounts of testing that the primary structure does.'

The company has designed a system whereby graphene powder is mixed into the resin to create a master batch. 'This involves loading the material up to very high concentrations, say 25% by

FIGURE 2

Haydale is working with a number of end-users including Briggs Automotive on the Mono supercar.

Please cite this article in press as: L. Nickels, Reinf. Plast. (2016), http://dx.doi.org/10.1016/j.repl.2016.06.004