Functionalized interleaved technology in carbon-fibre-reinforced composites for aircraft applications

Lin Ye

At the recent 19th International Conference of Composite Materials (ICCM-19), in Montreal, Professor Xiaosu Yi from the Beijing Institute of Aeronautical Materials, Aviation Industry Corporation of China, gave a plenary lecture on ‘How to Make the Structural Composites Multi-functional’. His lecture highlighted the recent developments from his research team in functional interleave technology (FIT). Their work has improved both the electrical conductivity and the impact resistance of carbon-fibre-reinforced composites for aircraft applications.

Carbon-fibre-reinforced polymer (CFRP) and glass-fibre-reinforced polymer (GFRP) composite structures are widely used in today’s aerospace, green energy, marine, sport and transportation industries. These materials provide manufacturers and builders with cost-competitive alternatives to conventional metal alloys. However, the introduction of polymer composites in mainframes of modern structures presents special challenges and issues regarding their multi-functional properties (e.g. electrical and thermal conductivities) in addition to the potential risk of incurring extension of interlaminar damage under impact and fatigue loading, due to the brittle nature of the matrix resin. For example, such composite structures are poor conductors of extreme electrical currents generated by a lightning strike. Composite materials are either not electrically conductive at all under a moisture-free condition (e.g. GFRPs with electrical conductivity in the order of $10^{-16} \text{[S m}^{-1}]$) or are significantly less conductive (e.g. CFRPs with the order of $10^6$–$10^7 \text{[S m}^{-1}]$) than metals (with the order of $10^6$–$10^7 \text{[S m}^{-1}]$).

Two approaches of FIT were detailed in Professor Yi’s lecture. The first approach is associated with the use of perforated amorphous phenolphthalein poly-ether-ketone (PEK-C) films as interleaves [1,2]. When an interleaved composite laminate with a thermosetting matrix (e.g. bismaleimide) is cured, highly toughened thin interlaminar regions are established with phase inversion and phase separation. The key advantage of such a technique is the black box of the reprogramming process.

In summary, focusing on genetic and chemical replacements of OCT4 in reprogramming, Deng and colleagues discovered a new logic and a chemical cocktail for reprogramming to pluripotency. Deng’s group represents one of many laboratories in China that have been making major contributions to the fields of reprogramming, stem cell biology and regenerative medicine. Given the major drive in China for biomedical research, more landmark discoveries will surely be forthcoming, moving closer to the dream of eternal youth.

Hongjun Song and Guo-li Ming
Institute for Cell Engineering, Departments of Neurology and Neuroscience, Johns Hopkins University School of Medicine, Baltimore, MD, USA
*Corresponding author.
E-mail: shongju1@jhmi.edu

doi: 10.1093/nsr/nwt007
Advance access publication 6 December 2013

REFERENCES
1. 潘国荣·《黄帝内经·素问》“可使病愈而复返于正者也”.
that it can significantly increase the interlaminar fracture toughness of carbon-fibre-reinforced thermosetting matrix composites by interleaving selectively in the interlaminar regions.

The second approach is the use of interleaf (e.g., perforated PEK-C film or polyamide veil) coated with conducting silver nanowires (AgNWs) of 70 nm in diameter and 300–1000 in aspect ratio [3]. The AgNWs are dispersed in an isopropanol to prepare a coating slurry. The film or veil is then dipped in the slurry, followed by a drying process to produce an interleaf surface with AgNWs attached. The tailored areal density of AgNWs loaded onto the PEK-C film is about 1.18 g m\(^{-2}\). The electrical percolation threshold of the surface-loaded films is about 0.3 g m\(^{-2}\). The AgNWs are densely interconnected with each other to form a conductive network (like a ‘spider-web’, Fig. 1) on the veil or film surface and even across the film thickness with the AgNW network at the edge of perforated holes. As the veil is highly porous, after surface loading, AgNWs are deposited onto almost all of its surface. In this way, two interdependent network structures co-exist at different scales. On the one hand, the film or veil framework at the micron scale is essential for interleaf toughening, with a substantial improvement in interlaminar fracture toughness, \(G_{IC}\) and \(G_{IIC}\). On the other hand, it provides a mechanism for adding nanoscale AgNWs. Thus, a nanoscale, 3D cross-linked AgNW network is established throughout the whole composite, providing a clear improvement in electrical conductivity in the transverse and thickness directions of the carbon fibre composites.

Professor Yi’s team will continue to study the electromagnetic interference shielding and lightning strike protection of carbon-fibre-reinforced composites using the FIT, advancing the fundamentals and engineering science embedded in the technology.

Lin Ye
School of Aerospace, Mechanical and Mechatronic Engineering and Centre for Advanced Materials Technology, University of Sydney, Australia
E-mail: lin.ye@sydney.edu.au

REFERENCES

doi:10.1093/nsr/nwt005
Advance access publication 17 December 2013

Natural pedogenic pathway of iron oxides

Rixiang Zhu

The exact formation pathway of iron oxides via pedogenesis has long been a contentious topic in geological and environmental studies [1]. Pedogenesis is crucial to accurately interpret the environmental significances of iron oxides in paleoclimatic archives, for example, the Chinese Loess/Paleosol sequences [2]. Several models have been developed but all lack direct constraints from natural records [2].

Hu et al. adopted a novel approach by integrating rock magnetism, dynamic dissolution and diffuse reflectance spectroscopy techniques [3]. They successfully separated and quantified major iron oxides of different origins (detrital and pedogenic) from a loess–paleosol–loess transition sequence of the classic Luochuan Loess section in Shaanxi, China.