Talga graphene boosts composite conductivity and saves weight in lightning strike protection

- **Tests demonstrate potential for Talphene®-enhanced composites to serve as alternative to copper in composite aircraft and wind turbine applications**
- **Conductivity results showing 500% increase in dielectric constant over reference and anti-icing surface temperatures well in excess of 100ºC without damage**
- **Saves 75% weight of standard copper-mesh while maintaining similar aircraft lightning strike protection performance**

Australian advanced materials technology company, Talga Resources Ltd ("Talga" or "the Company")(ASX: TLG), has achieved outstanding conductivity results from Talphene®-enhanced epoxy composite trials undertaken at TWI in the UK.

Carbon fibre reinforced polymer ("CFRP") panels were constructed using a dispersion of Talga graphene (Talphene®) in the epoxy based resin of the composite and subjected to a range of conductivity tests pertinent to aircraft applications.

Results showed the Talphene® panel provided similar lightning strike protection as copper mesh panels currently used in composite aircraft but saved 75% of the weight of the copper (Figs 1,2 and Table 1). Further results demonstrating Talphene®'s significant conductivity included up to 500% increase in dielectric constant, 100% increase in resin thermal conductivity as well as spot temperatures well over 100 degrees celsius in anti-icing trials (Fig 3). As CFRP resins are normally non-conductive, these results are highly positive.

The ability to improve the weight, electrical and thermal conductivity of CFRP composites has significant benefits for applications such as lightning strike protection and wing anti-icing on aircraft, both of which currently use heavy copper mesh. The same technology would also be of benefit to wind turbine blades that require manual or chemical de-icing in winter (Fig 4).

Figure 1 Managing Director, Mark Thompson and Chief Technology Officer Dr Siva Bohm showing some of the CFRP test panels after lightning strike tests (Talphene® panel on right in both photos).

Note the rear of the Talphene® panel (far right) shows no exit puncture. The copper mesh panel shows damage from further testing but would also otherwise show no puncture.

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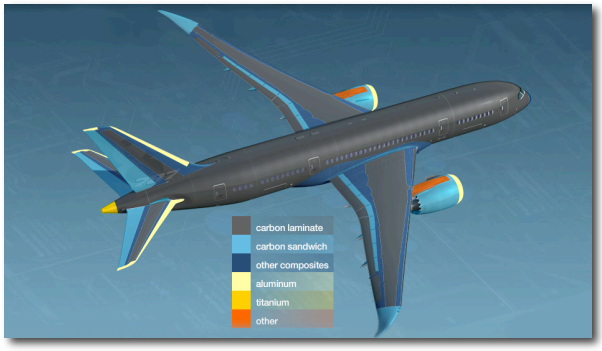
Talga Managing Director, Mr Mark Thompson: *"Tests show that Talphene®-enhanced conductive composites can do the same job as copper, but with less weight, easier application and therefore potentially much lower lifetime costs. These highly encouraging outcomes follow our earlier test results showing increased strength and toughness of epoxy resins and we can now move to addressing the full range of market opportunities for Talphene® products across the composites sector."*

Composite Tests

Talga graphene enhanced epoxy composite prototypes were tested at TWI, a respected material science and engineering institute near Cambridge, UK, and Cobham Technical Services under certified aerospace standard laboratory conditions.

The prototype formulation was prepared using Talphene® produced from the Company's Vittangi graphite deposit in Sweden and dispersed using a proprietary method developed by Talga Technologies Limited in the UK.

Figure 2 CFRP is used throughout the body of many modern aircraft. Copyright © Boeing



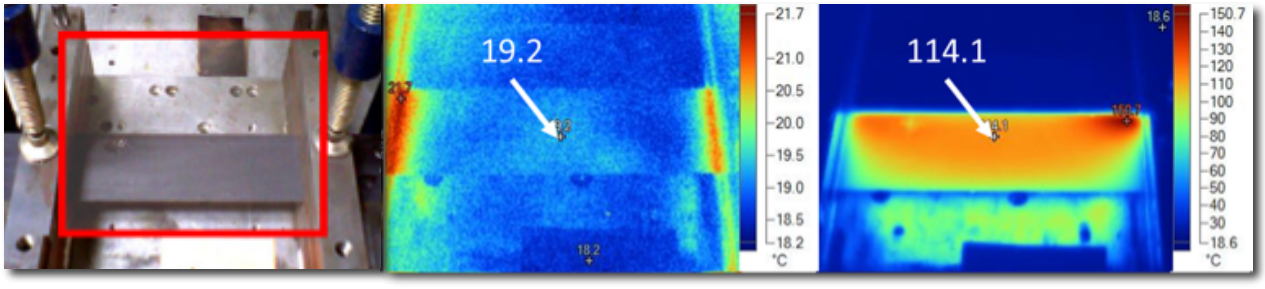
The program assessed epoxies from Hexcel, 3M, Bitrez and Huntsman with which to disperse the Talphene® and construct the CFRP samples to be tested.

Tests were conducted on 600mm x 600mm, three-ply CFRP panel samples measuring electrical properties by dielectric constant, thermal conductivity according to ISO8301:1991 Ed1, lightning strike tests at Cobham Technical Services according to EUROCAE ED-105A to Zone 2A strike specification and anti-icing tests by Joule heating using MacGregor power supply and thermal imaging. SEM and optical microscopy confirmed dispersion of the Talphene® into the resin.

Table 1 *Summary of Cobham Technical Services lightning strike test data showing similar performance of Talphene® enhanced CFRP panel to that using copper mesh.*

Shot	Panel	Peak injected current (kA)	Action Integral (MJ/Ω)	Charge Transfer (C)	Result
1	Copper Mesh Panel	102.7	0.23	28.2	No Puncture
2	Talphene® Panel 8	97.1	0.21	27.6	No Puncture
3	Talphene® Panel 9	97.6	0.22	27.0	No Puncture

Figure 3 Anti-icing tests of Talphene® enhanced CFRP panel using an electric current (Left) with thermal imagery showing temperature at rest (Centre) and under voltage (Right).



Composite Market

The global composite market is worth over USD$82 billion/year[1] and is rapidly growing across sectors in aerospace, renewable energy and automotive markets driven by increased demand for lower weight, higher strength and multi-functionality.

By 2024, the total volume of the CFRP composite material market is predicted to be in excess of 290,000 tonnes[2]. Key producers include companies such as Toray, Toho Tenax, Mitsubishi, Hyosung, Cytec, Plasan, Hexcel Corp, SGL (Germany), Gurit (Switzerland) and Formosa Plastics Corporation.

Figure 4 Example of expensive and high enviro-impact chemical de-icing of wind turbine blades in northern hemisphere winter. Turning the CFRP blade into a self-powered heating element offers a better solution.

Moving Forward

Graphene enhanced composites are one of the four key sectors of Talga's commercialisation strategy and these test results validate the Company's focus and potential in this sector. Talga will now progress its products in the composites market using these prototype test results as the catalyst to initiate joint development and commercial agreements with global end users.

About Talga

Talga Resources Ltd is an advanced materials technology company enabling stronger, lighter and more functional products for the multi-billion dollar global coatings, battery, construction and polymer composites markets via graphene and graphite products. The company has significant advantages owing to its 100% owned unique high grade graphite deposits in Sweden and in-house processing and product technology. Joint development programs are underway with a range of international corporations. Company website: www.talgaresources.com

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References

1 JEC Group "Overview of the global composites market - at the crossroads, 2017"

2 Global Market Insights "Carbon Fibre Composites Market Size By End-Use, Oct 2017"

TECHNICAL GLOSSARY

Abrasion resistance	The ability of a material to resist wearing due to contact with another surface
Adhesion strength	The tendency of dissimilar surfaces to cling to one another
Carbon Fibre	Reinforcing fibre known for its light weight, high strength and high stiffness
Carbon Fibre Reinforced Polymer (CFRP)	A very strong, light weight composite in which Carbon constitutes the reinforcing fibres, the matrix resin system will usually be epoxy, polyester, vinyl ester or nylon
Coating	A covering that is applied to the surface of the substrate in order to provide a functional (e.g. anticorrosion) or decorative value
Composite	A material made from two or more constituent materials
Dielectric constant	The measure of a material's ability to store a charge when an electric field is applied
Ductility	The ability of a material to stretch into a form of a wire
Electrochemical impedance Spectroscopy (EIS)	An non-destructive test aimed at finding the impedance (or resistance) of a coating system against corrosion using an alternating current
Electrochemical tests	Test evaluation involving electrical and chemical processes and their interaction
Elongation	The amount of lengthening of a material under force and is often regarded as a measure of material's ductility
Epoxide group	A three atom ring containing oxygen at one of the corners
Epoxy resin	A class of reactive prepolymers and polymers which contain epoxide group that can crosslink with a wide range of co-reactants to form hardened thermosetting polymers with high mechanical properties and chemical resistance
Graphene	A single atom thick layer of crystalline carbon, with properties of strength, conductivity and transparency that stem from its unique 2D structure
Inorganic zinc epoxy	An anticorrosive inorganic coating containing Zinc metal chemically bonded with the silicate resin
Linear polarisation	An destructive test aimed at finding the corrosion rate of a coated material using direct current
Optical Microscopy	An analytical technique in which prepared samples are examined at different magnifications and types of light
Polymer	A large molecule, or macromolecule, composed of many repeated smaller molecules or subunits

Scanning Electron Microscope (SEM)	An instrument which scans or rasters a fine electron probe over a material, and using a variety of detectors reconstructs an image from the signals generated within the sample.
Tensile strength	The capacity of a material or structure to withstand loads tending to elongate
Zinc	Metal used to protect steel against corrosion
Zinc rich epoxy	An anticorrosive organic coating containing Zinc metal dispersed in a polymeric resin (usually epoxy)