

## Talga develops performance enhancing graphene technology for large volume epoxy resin markets

### Talga Resources Ltd

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### Corporate Information

ASX Codes **TLG, TLGOA**

Shares on issue **202.4m**

Options (listed) **44.9m**

Options (unlisted) **33.5m**

### Company Directors

#### Terry Stinson

Non-Executive Chairman

#### Mark Thompson

Managing Director

#### Grant Mooney

Non-Executive Director

#### Stephen Lowe

Non-Executive Director

#### Ola Mørkved Rinnan

Non-Executive Director

- Talga graphene boosts performance of epoxy resins used widely in global coatings industry.
- Key performance gains in first tests against control epoxy coatings include:
  - ▶ 160% increase in tensile strength;
  - ▶ 80% increase in abrasion resistance; and
  - ▶ 2 orders of magnitude decrease in corrosion rate over zinc-rich epoxy.
- Patent lodged over Talga's graphene enhanced epoxy formulation and dispersion technology.
- Technology has the potential to materially impact the 2.5 million tonne per annum global epoxy market that includes coatings, adhesives and carbon fibre-reinforced plastics.

Australian technology minerals company, Talga Resources Ltd ("Talga" or "the Company")(ASX: TLG), is pleased to announce positive initial test results from epoxy resin-based coatings formulated using Talga's Talphene® branded graphene.

Epoxy based coatings are used in a myriad of applications, from internal concrete flooring to urban construction products, and they particularly suit anti-corrosion applications. For this reason, epoxy-based coatings dominate steel protection for marine exposed infrastructure such as bridges, pipelines, oil and gas platforms & ship infrastructure and hulls (Figure 1).

Talga's tests used a formulated dispersion of Talga's few layered graphene (FLG) and graphene nanoplatelets (GNP), mixed into a two-part epoxy resin (a type of thermoset polymer) used widely in marine coating systems.

Initial test results show significantly improved coating performance attributes including higher corrosion resistance, increased mechanical strength and higher abrasion resistance compared to the control coatings using commercial type zinc-rich epoxy (Figures 2-3 and Test Program details below).

These results are significant because improved overall coating performance translates to lower application and infrastructure maintenance costs, coupled with environmental benefits such as reduced toxic metals.

Talga's formulation coupled to its novel method of incorporation into the resin solves industry issues such as inhomogeneous distribution, and a provisional patent has been lodged to protect Talga's intellectual property ("IP"). Further, these improvements provide an opportunity to achieve similar benefits in other thermoset polymer composites such as carbon fibre reinforced plastics.

Talga is now moving to optimise its graphene epoxy technology in tests with independent industry organisations and has commenced an epoxy composite development program with the respected TWI materials and research group based in Cambridge, UK. The development program will test Talga's graphene epoxy technology against other commercial products, including high strength additives, for a number of functionalities including thermal and electrical conductivity. Results will lead to preparation of prototype material and data for industry partnerships.

**Talga Managing Director Mark Thompson commented:** *"These results further highlight the potential of Talga graphene in existing large volume industrial markets. By substituting current active ingredients such as zinc with lower quantities of higher performing non-toxic graphene alternatives, the application, environmental and maintenance costs of steel vessels and infrastructure can be reduced.*

*"Talga's technology relates both to its formulation and, importantly, the method of incorporating the graphene. This area has caused issues for industry uptake in the past but our proprietary dispersion technology looks to be a breakthrough for epoxy resins. These results also provide confidence to apply Talga's graphene epoxy technology more widely to the fibre-reinforced polymer composite industry that includes aerospace and automotive sectors."*



**Figure 1** Epoxy based coatings dominate steel protection systems for marine vessels and infrastructure.





## Epoxy Resin Background

The term composite refers to the interaction between two or more materials. Protective coatings are typical large-scale examples of composite materials, where one or more materials are dispersed/cross-linked with a polymeric resin.

Epoxies are two-part polymeric resins, requiring a resin and curing agent (hardener) to catalyse and produce a tough, chemical and solvent-resistant solid. Their corrosion-resistivity, high mechanical strength, chemical resistance and thermal/electrical resistivity make them suitable for use in many protective coatings. Bisphenol A, Bisphenol F and phenolic 'Novolac' are the major epoxy resins used in the manufacturing process of epoxy protective coatings (see Technical Glossary).

Graphene, with its high strength/weight ratio, impermeability, chemical inertness and high surface area has been demonstrated to result in higher performing and/or more enviro-friendly polymer matrices when used as an additive. Thus a considerable amount of prior work has been undertaken globally on the incorporation of graphene into epoxy resins. However, positive results have often been coupled with associated negative performance across some attributes through inhomogeneous distribution of the graphene particles and non-desirable viscosity changes during application.

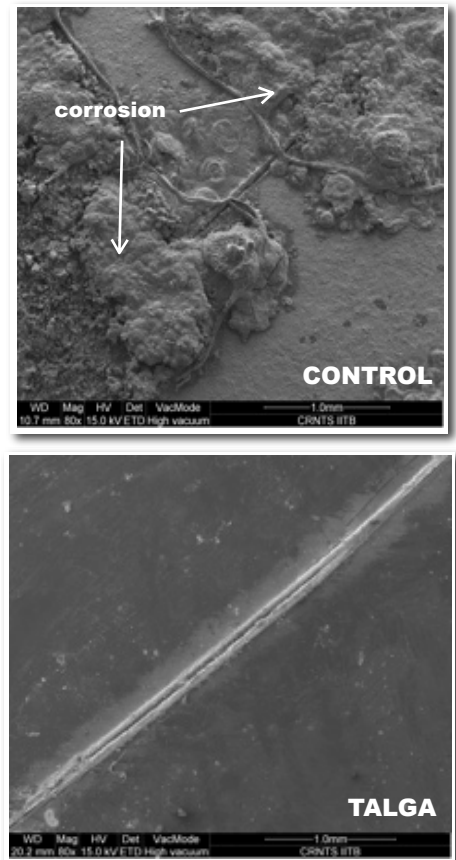
## Test Program

Talga's first stage test-work has been completed on two-pack epoxy polymer resins for the marine coating market.

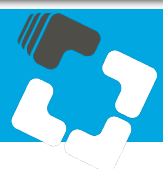
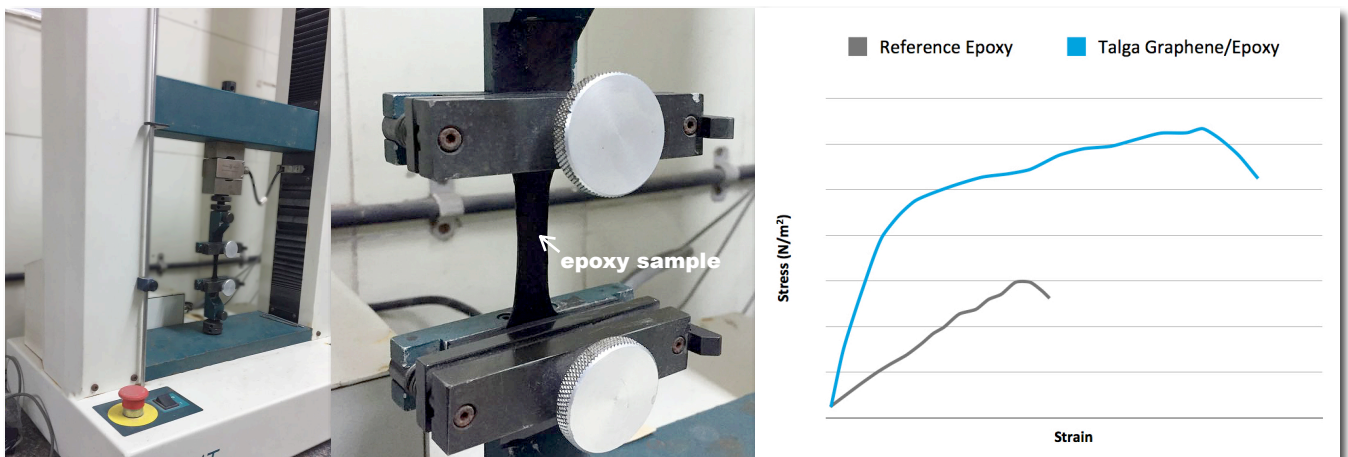
"Bisphenol A" based epoxy resin was the base matrix used for the test program. Formulations containing Talga graphene in a range of concentrations were prepared, incorporated with the base matrix and applied on standard mild steel (MS) panels for performance testing. A free film of these formulations was also made to evaluate tensile properties.

Commercially available zinc rich epoxy primer (75% v/v zinc) was used as control for the corrosion test systems. Electrochemical tests (Electrochemical Impedance spectroscopy and Linear Polarisation) demonstrated (under ASTM G59 standard) that incorporation of Talga graphene in epoxy resin decreases the corrosion rate of the underlying mild steel by two orders of magnitude compared to zinc rich based marine coatings.

**Figure 2** Scored-coating salt water immersion test showing corrosion performance of zinc epoxy (top) versus Talga graphene enhanced epoxy (bottom).

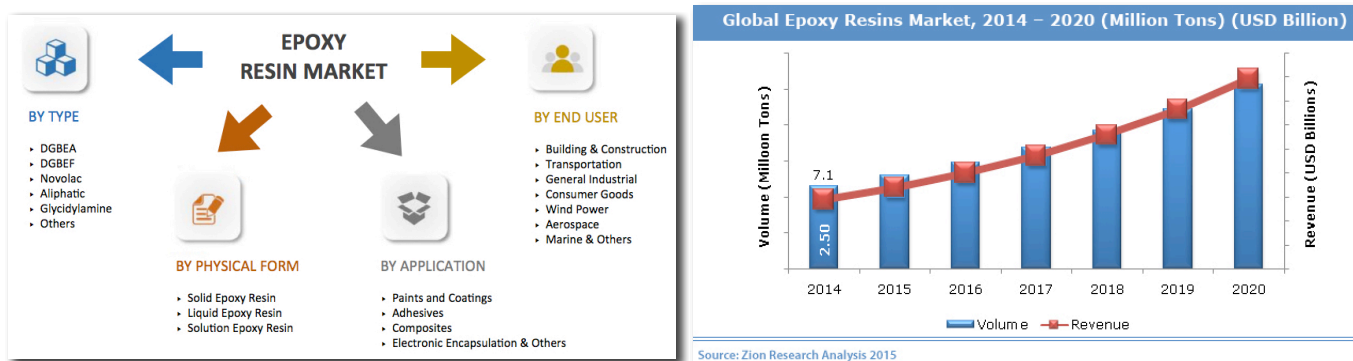


**Figure 3** Tensile and elongation testing of Talga graphene epoxy resin under ASTM B882 standard.



Coating abrasion resistance (tested under standard ASTM D 4060) improved by 80% over control epoxy coatings (top coat). The free film was cut to shape and strength tested, whereby improvements in tensile strength (160%) and elongation (95%) were recorded (under standard ASTM B882). Due to patent considerations the loadings of graphene in the formulations and other technology and performance details cannot be disclosed at this time. Next stage test-work will investigate the ability to transfer this IP to other composite resin applications.

**Figure 4** Global epoxy resin market overview, volume and revenue data.



### Market

The total global epoxy sector consumed approximately 2.5 million tonnes of epoxy resins in 2014<sup>a</sup> (Figure 4). Within this market, the protective coatings sector alone (Figure 5) is estimated to be valued at USD\$7.8 billion (2016) and projected to reach USD\$9.9 billion by 2021, at an estimated CAGR of 4.8%<sup>b</sup>.

Epoxy protective coatings are widely used to layer various metal substrates in the oil & gas industry, marine, aerospace & automotive industry, among others. It is also used for floor coatings and numerous other household and commercial applications owing to its excellent adhesion, abrasion resistance and water-resistivity properties. Increasing industrialisation in various countries, such as China and India is boosting the demand for urban infrastructure and automotive materials that use epoxy based protective products<sup>c</sup>.

The key players in this market are Olin Corporation (U.S.), Nan Ya Plastics Corporations (Taiwan), Kukdo Chemical Co. Ltd. (Korea), Hexion Inc. (U.S.), Chang Chun Plastics Ltd. (Taiwan), Huntsman Corporation (U.S.), BASF SE (Germany), 3M (U.S.), Mitsubishi Chemical Corp. (Japan), Atul Ltd. (India), Sinopec Corp. (China), Solvay (Europe), PPG (U.S.), Sherwin Williams Co. (U.S.), Akzo Nobel Coatings (Europe) and Aditya Birla Chemical (Thailand), among others<sup>d</sup>.

For further information, visit [www.talgaresources.com](http://www.talgaresources.com) or contact:

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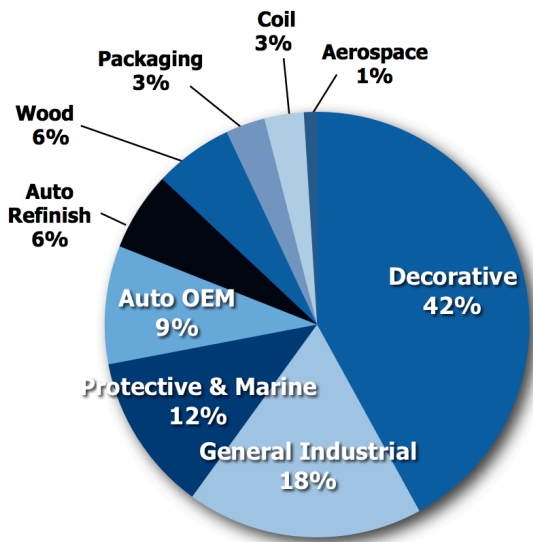
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### References

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- b Epoxy Resins Market 2015, Allied Market Research.
- c Metal Finishing Market - Trends and Forecasts (2015-2020) Aug 2016, Mordor Intelligence.
- d Epoxy Resin Market Analysis By Application (Paints, Wind Turbine, Composites, Construction, Electrical & Electronics, Adhesives) And Segment Forecasts To 2024, Grandview Research.

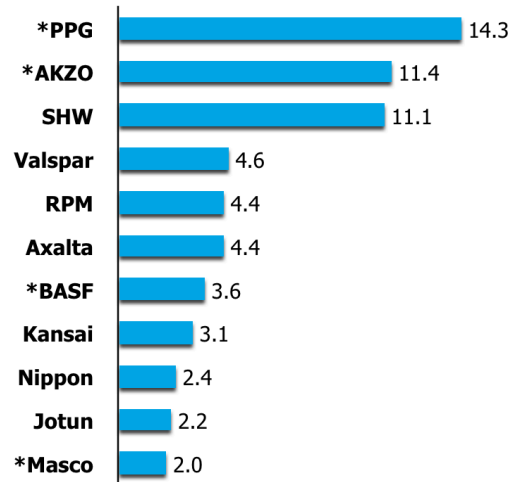
Figure 5 Paints and coatings global market (2016).

**Total Paints and Coatings Market : \$120 Billion**



Source: Jan 2016 Valspar Investor Presentation after 2013 Orr & Boss, Kusumgar, Nerlifi & Growney

**Global Leaders by Sales (\$Billion)**



Source: Jan 2016 Valspar Investor Presentation & Company reports. \* Excludes non-coating sales

**About Talga**

Talga Resources Ltd (“Talga”) (ASX: TLG) is a technology minerals company enabling stronger, lighter and more functional graphene and graphite enhanced products for the multi-billion dollar global coatings, battery, construction and carbon composites markets. Talga has significant advantages owing to 100% owned unique high grade conductive graphite deposits in Sweden, a test processing facility in Germany and in-house product development and technology. Advanced product testing is underway with a range of international corporations including industrial conglomerate Chemetall (part of BASF), Heidelberg Cement, Tata Steel, Haydale, Zinergy and Jena Batteries.



## TECHNICAL GLOSSARY

<b>Abrasion resistance</b>	The ability of a material to resist wearing due to contact with another surface.
<b>Adhesion strength</b>	The tendency of dissimilar surfaces to cling to one another
<b>Coating</b>	A covering that is applied to the surface of the substrate in order to provide a functional (e.g. anticorrosion) or decorative value
<b>Composite</b>	A material made from two or more constituent materials
<b>Ductility</b>	The ability of a material to stretch into a form of a wire
<b>Electrochemical impedance Spectroscopy (EIS)</b>	An non-destructive test aimed at finding the impedance (or resistance) of a coating system against corrosion using an alternating current
<b>Electrochemical tests</b>	Test evaluation involving electrical and chemical processes and their interaction
<b>Elongation</b>	The amount of lengthening of a material under force and is often regarded as a measure of material's ductility
<b>Epoxide group</b>	A three atom ring containing oxygen at one of the corners
<b>Epoxy resin</b>	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
<b>Graphene</b>	A single atom thick layer of crystalline carbon, with properties of strength, conductivity and transparency that stem from its unique 2D structure.
<b>Inorganic zinc epoxy</b>	An anticorrosive inorganic coating containing Zinc metal chemically bonded with the silicate resin
<b>Linear polarisation</b>	An destructive test aimed at finding the corrosion rate of a coated material using direct current
<b>Polymer</b>	A large molecule, or macromolecule, composed of many repeated smaller molecules or subunits.
<b>Tensile strength</b>	The capacity of a material or structure to withstand loads tending to elongate
<b>Zinc</b>	Metal used to protect steel against corrosion
<b>Zinc rich epoxy</b>	An anticorrosive organic coating containing Zinc metal dispersed in a polymeric resin (usually epoxy)

