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Graphene Oxide, Applications and Markets Perspectives

Graphene oxide (GO) has a long history, first prepared by Brodey already 158 years ago[1], but by then and until recently named graphitic oxide. GO has several unique and useful properties but has so far not found any large scale industrial application. One of the fundamental problems up to now has been the risk of explosive runaway in its production, although reduced with the synthesis method of Hummers and Offeman[2]. Today, safe production has been established, opening for large scale production and industrial applications.
GO is fundamentally different from ideal graphene in that it is non-conductive and hydrophilic. However, it can easily be reduced to graphene-like "reduced graphene oxide" rGO by thermal, chemical or light induced methods. Fully reduced rGO is graphene-like in that it consists of pure carbon and is highly hydrophobic, although with a high proportion of defects. However, rGO is most often only partly reduced, to different degrees, and as such fills the gap between GO and graphene, constituting a family of materials from only slightly conductive, amphiphilic to higly conductive hydrophobic materials.
Reported applications of GO and rGO include water treatment and de-salination, polymer composites, ultracapacitors and batteries, bone replication scaffolds, sensors, rust protection and conductive coatings. Researchers at Rice University reported in 2013 the use of GO to soak up heavy radionuclides from water[3]. This is certainly one of the applications to be seen commercialized in this decade, easily requiring production of hundreds of tons of GO per year. On the other hand, applications as components in sensors, although potentially large in numbers will be small in mass due to the very limited amount used in each sensor. When it comes to energy storage, reduced graphene oxide (rGO), effectively compeets with other graphene powders.
Interesting results with use of graphene, GO and rGO for scaffolds for growth and differentiation of stem-cells have now been confirmed by multiple reports, potentially opening up for new approaches in regenerative medicine[4]. There are also reports on use of GO's resistive properties in insulation for electrical cables.
Polymer composites represent another large potential market for GO and rGO, in part in competition with other graphene type powders. Here, the target properties as well as ease of dispersion of the composite will determine which variety of graphene type material is preferred.
Abalonyx is active in production of GO and rGO as well as in the development of GO and rGO optimized for several applications and some GO and rGO containing composite materials and Abalonyx' sister company Graphene Batteries is engaged in application of rGO and pillared rGO for certain battery and supercapacitor applications with promising results, to be reviewed.
The final, and not least important parameter for large scale use of GO and rGO is price. Present estimates indicate that the price of GO can come down to well below 40 USD/Kg and rGO to just under 100 USD/Kg – price levels that can be tolerated by many industries if compensated by substantial improvements in performance of the GO/rGO-containing products.

References

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