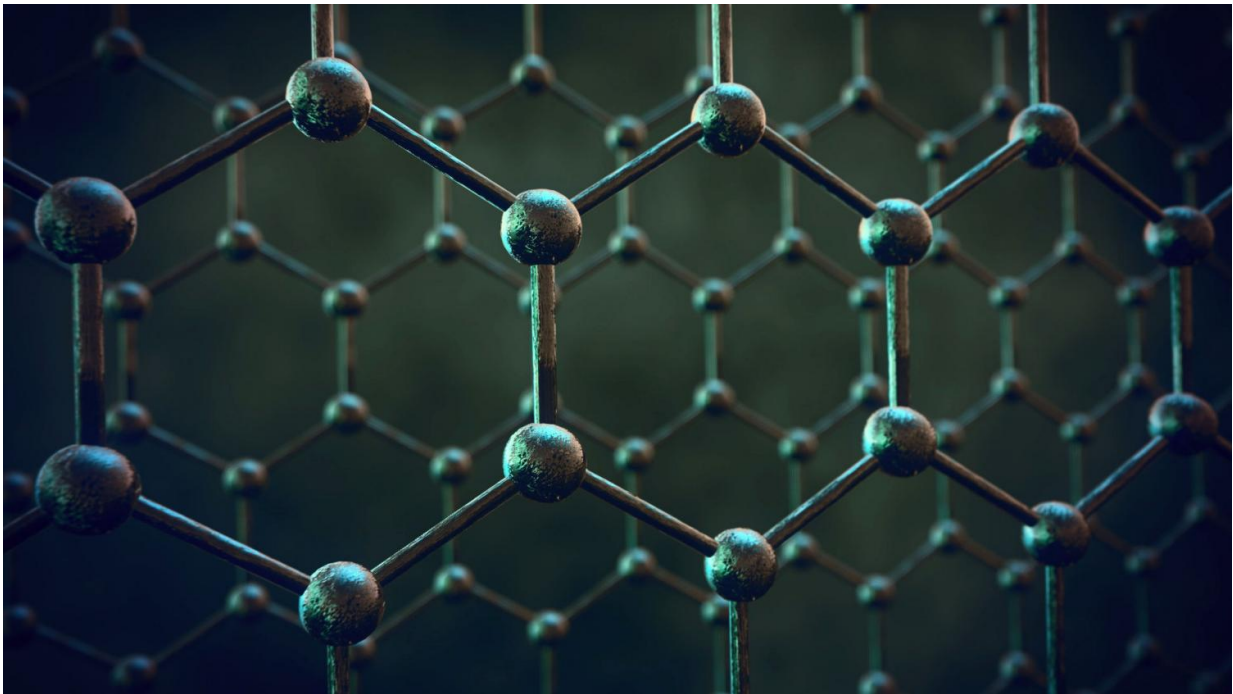


# Natural human enzyme can biodegrade graphene, scientists report

August 24 2018, by nishad Karim

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This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

Degradation of pristine graphene occurs in the human body when interacting with a naturally occurring enzyme found in the lung, announced Graphene Flagship partners; the French National Centre for Scientific Research (CNRS), University of Strasbourg, Karolinska Institute and University of Castilla–La Mancha (UCLM).

Graphene-based products, including flexible biomedical electronic devices, are being designed for interface with the human body within the Graphene Flagship. If [graphene](#) is to be used for such biomedical applications, it should be biodegradable and thus be expelled from the body.

To test how graphene behaves within the body, Alberto Bianco and his team at Graphene Flagship partner CNRS conducted several tests to determine whether and how graphene was broken down with the addition of a common human enzyme. The enzyme, myeloperoxidase (MPO), is a peroxide enzyme released by neutrophils, cells found in the lungs that are responsible for the elimination of foreign bodies or bacteria that enter the body. If a foreign body or bacteria is detected inside of the body, neutrophils surround it and secrete MPO, thereby destroying the threat. Previous work by Graphene Flagship partners found MPO to biodegrade graphene oxide. However the structure of non-functionalized graphene was thought to be more degradation resistant. To test this, Bianco and his team looked at the effects of MPO, *ex vivo*, on two graphene forms: single- and few-layer.

Bianco says, "We used two forms of graphene—single- and few-layer, prepared by two different methods in water. They were then taken and put in contact with myeloperoxidase in the presence of hydrogen peroxide. This peroxidase was able to degrade and oxidise them. This was not really expected, because we thought that non-functionalized graphene was more resistant than graphene oxide."

Rajendra Kurapati, first author on the study, from Graphene Flagship partner CNRS, said, "The results emphasize that highly dispersible graphene could be degraded in the body by the action of neutrophils. This would open the new avenue for developing graphene-based materials."

In-vivo testing is the next stage. Bengt Fadeel, professor at Graphene Flagship partner Karolinska Institute, says, "Understanding whether graphene is biodegradable or not is important for biomedical and other applications of this material. The fact that cells of the immune system are capable of handling graphene is very promising."

Prof. Maurizio Prato, leader of Work Package 4, said, "The enzymatic degradation of graphene is a very important topic, because in principle, graphene dispersed in the atmosphere could produce some harm. Instead, if there are microorganisms able to degrade graphene and related materials, the persistence of these materials in our environment will be strongly decreased. These types of studies are needed. What is also needed is to investigate the nature of degradation products. Once graphene is digested by enzymes, it could produce harmful derivatives. We need to know the structure of these derivatives and study their impact on health and environment."

Prof. Andrea C. Ferrari, Science and Technology Officer of the Graphene Flagship, and chair of its management panel, added, "The report of a successful avenue for graphene biodegradation is a very important step forward to ensure the safe use of this material in applications. The Graphene Flagship has put the investigation of the health and environment effects of graphene at the centre of its programme since the start. These results strengthen our innovation and technology roadmap."

**More information:** Rajendra Kurapati et al. Degradation of Single-Layer and Few-Layer Graphene by Neutrophil Myeloperoxidase, *Angewandte Chemie International Edition* (2018). [DOI: 10.1002/anie.201806906](https://doi.org/10.1002/anie.201806906)

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Provided by Graphene Flagship

Citation: Natural human enzyme can biodegrade graphene, scientists report (2018, August 24) retrieved 25 April 2024 from <https://phys.org/news/2018-08-natural-human-enzyme-biodegrade-graphene.html>

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