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Liquid metal discovery ushers in new wave of chemistry and electronics

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This image of a liquid metal 'slug' and its clear atom-thick 'trail' shows the breakthrough in action. When dissolved in a liquid metal core, certain metals leave behind this clear layer of their oxide, which is no thicker than a few atoms and can be peeled away by touching or rolling. Credit: RMIT University

Researchers from RMIT University in Melbourne, Australia, have used liquid metal to create two-dimensional materials no thicker than a few atoms that have never before been seen in nature.

The incredible breakthrough will not only revolutionise the way we do chemistry but could be applied to enhance data storage and make faster electronics. The "once-in-a-decade" discovery has been published in *Science*.

The researchers dissolve metals in liquid metal to create very thin oxide layers, which previously did not exist as layered structures and which are easily peeled away.

Once extracted, these oxide layers can be used as transistor components in modern electronics. The thinner the oxide layer, the faster the electronics are. Thinner oxide layers also mean the electronics need less power. Among other things, oxide layers are used to make the touch screens on smart phones.

The research is led by Professor Kourosh Kalantar-zadeh and Dr Torben Daeneke from RMIT's School of Engineering, who with students have been experimenting with the method for the last 18 months.

"When you write with a pencil, the graphite leaves very thin flakes called graphene, that can be easily extracted because they are naturally occurring layered structures," said Daeneke. "But what happens if these materials don't exist naturally?

"Here we found an extraordinary, yet very simple method to create atomically thin flakes of materials that don't naturally exist as layered structures.

"We use non-toxic alloys of gallium (a metal similar to aluminium) as a reaction medium to cover the surface of the liquid metal with atomically thin oxide layers of the added metal rather than the naturally occurring gallium oxide.

"This oxide layer can then be exfoliated by simply touching the liquid metal with a smooth surface. Larger quantities of these atomically thin layers can be produced by injecting air into the liquid metal, in a process that is similar to frothing milk when making a cappuccino."

It's a process so cheap and simple that it could be done on a kitchen stove by a non-scientist.

"I could give these instructions to my mum, and she would be able to do this at home," Daeneke said.

Metal droplets leave no thin layer of oxide skin on the surface, if this oxide skin is dissolved in an alkali base or acid. Credit: RMIT University

Professor Kourosh Kalantar-zadeh said that the discovery now places previously unseen thin oxide materials into everyday reach, with profound implications for future technologies.

"We predict that the developed technology applies to approximately one-third of the periodic table. Many of these atomically thin oxides are semiconducting or dielectric materials.

"Semiconducting and dielectric components are the foundation of today's electronic and optical devices. Working with atomically thin components is expected to lead to better, more energy efficient electronics. This technological capability has never been accessible before."

The breakthrough could also be applied to catalysis, the basis of the modern chemical industry, reshaping how we make all chemical products including medicines, fertilisers and plastics.

More information: "A liquid metal reaction environment for the room-temperature synthesis of atomically thin metal oxides" *Science* (2017). science.sciencemag.org/cgi/doi … 1126/science.aao4249

Provided by RMIT University

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