New 2D materials promise significant sound noise reduction.

Scientists have discovered a new 2D material with the potential to reduce EMI interference, improve battery life, and enhance audio applications, based on rigorous scientific research.

Scientists have just announced a brand-new 2D material with the potential to reduce noise, improve battery life, and shield against electromagnetic interference (EMI). Importantly, this research is based on solid scientific evidence, not vague advertising claims like 'snake oil'.

A research team led by Professor Huang Qing at the Ningbo Institute of Materials Technology & Engineering (NIMTE), under the Chinese Academy of Sciences, has found a new way to 'modify' the internal structure of **MAX phases** – a family of layered compounds. The work, published in *Nature Synthesis* , shows that this breakthrough could pave the way for new two-dimensional (2D) materials with applications in batteries, catalysts, and especially **electromagnetic interference (EMI) shielding** .

This is a particularly noteworthy point in the audio market, as a low noise floor is always one of the most sought-after features by audiophiles. In fact, many people have spent a lot of money on cables and equipment, even on products considered 'snake oil' – expensive but lacking clear scientific basis.

What are MAX phases – and why are they so difficult to 'process'?

MAX phases are compounds consisting of **early transition metals** combined with **carbon or nitrogen** , arranged in a layered structure. This characteristic makes them ideal for creating 2D materials that are only a few atoms thick.

A well-known group of 2D materials derived from MAX phases is **MXenes** , typically created by removing metal atoms at the A-site. However, when the A-site is occupied by nonmetals **such** as oxygen, sulfur, or phosphorus, the M–A and M–X layers become **very strongly covalently bonded** , rendering conventional etching methods ineffective.

'Editing' atomic layers using heat and chemical reactions.

The research team discovered that these covalent layers react differently at high molten temperatures. Taking advantage of this difference, they restructured the sublayers, replacing the atom at the X position with nonmetals such as boron, selenium, sulfur, phosphorus, and carbon.

Furthermore, they demonstrated that acid Lewis cations can reduce the oxidation state of element M, thereby allowing for the attachment of more nonmetals and transforming MAX phases that previously lacked van der Waals bonds into layered van der Waals materials.

Professor Huang explained:

> By controlling the total enthalpy of formation of the reaction, we can deliberately replace atoms in the sublayer. This opens the way for designing layered materials with desired properties.

(Enthalpy is a concept in physical chemistry used to describe the total heat energy of a system. In this study, controlling enthalpy helps the reaction proceed in the desired direction and with the desired structure.)

TMXCs – a promising new family of 2D materials.

Using the above method, the team created a new family of compounds called **TMXCs** (early transition metal chalcogenide carbides/nitrides). These materials combine the characteristics of **MXenes** and **transition metal dichalcogenides (TMDs)** .

In monolayers, the atomic structure of TMXCs is quite similar to MXenes, but **the oxidation state of the M atom** can be flexibly adjusted by the substitution of the X atom and intercalated cations. The group also demonstrated that TMXCs can be **separated into single-atom-thick nanosheets** , thanks to 'chemical pullers' for electrons – creating ultrathin sheets of material with unique properties.

Both experimental and simulation studies confirm that changing the element X in the M–X layer alters **the electronic structure** of TMXCs. This ability to control structure and properties makes them potential candidates for **electrochemical energy storage** , **batteries** , **catalysis** , and especially **electromagnetic interference (EMI) shielding –** a key factor in reducing noise in high-end audio systems.
