**Two-dimensional nanomaterials for sensing**

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Two-dimensional (2D) nanomaterials have attracted interest in recent times due to their promise in various applications. Graphene and other 2D materials have been extensively studied over recent decades as energy storage materials. One of the industry applications is as the anode of lithium ion batteries. A high surface to area ratio also makes 2D materials attractive for gas sensing.

The sensing mechanism of 2D materials for gases such as CO2, NH3, CH4, H2S, SO2 and NO2 is relatively simple and is mostly driven by electron (charge) transfer. If the material is a semiconductor with a band gap, then interaction with a gas will either increase or decrease the band gap, and consequently decrease or increase the conductivity, which can be measured. It should be noted here that strong bonding of the gas to the material is not required for good sensor performance. In fact, it is not desired that the gas binds strongly to the material, as this would poison the sensing material which means it will degrade and will not be reusable. There is a vast amount of possible materials available.

Carbon nitrides exist in a wide range of configurations and can be classified within the class of 2D covalent triazine frameworks (CTFs) and 2D covalent organic frameworks (COFs). Organic molecules are linked by covalent bonds to yield crystalline, porous COFs from light elements (boron, carbon, nitrogen, oxygen, and silicon) that are characterized by high architectural and chemical robustness. COFs feature highly structured porous sp2 networks and their conductivity can be tuned via functional groups.

This talk will discuss a range of 2D carbon nitrides and concentrate on the fundamental underlying properties of the material that enable sensing. The binding location of the gas on the material will determine the active part of the material. The binding strength of the gas with the material will reveal if the gas will form a bond with the material and therefore poison and degrade it. Weak binding (no bond formation) but a strong interaction to affect electron transfer, is the desired outcome.

Electron transfer between the gas and the material changes the electron distribution within the material and the gas. The gas can transfer electrons to the material which is expected to make its band gap smaller. When the gas obtains electrons from the material, the material’s band gap is expected to increase. Electron transfer is therefore important for the fundamental understanding of the effect of the active part on the sensing process.

The band gap determines the selectivity for a particular gas. The band gap is directly related to the conductivity of the material and this is the measurable property that is used in electrochemical sensors. The presence of the gas will decrease or increase the band gap which results in higher or reduced conductivity (a smaller band gap means the electrons have a shorter distance to jump, making their transfer easier). If the gas does not change the band gap, then the sensor cannot detect the gas.