National Chemistry Week Speaker:

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Polymeric Sensing Materials for Volatile Organic Compound Sensors

Monitoring various volatile organic compounds (VOCs) is important for a variety of applications. For example, ethanol detection to prevent a person from driving while intoxicated, acetone detection in disease diagnosis such as diabetes, and formaldehyde and benzene detection in indoor air quality. In any application, multiple VOCs are present and will interact with both the sensing materials and the other VOCs. This makes the identification of highly selective sensing materials difficult.

The "heart" of a sensor is the sensing material because that is what interacts with the analytes. Changing the sensing material will influence which analytes are able to interact with the sensor to produce a response. Polymers are great sensing materials since they have high environmental stability, operate at room temperature, and are relatively inexpensive. In addition, polymers can be tailored to selectively attract a target analyte by modifying their functional groups, through copolymerization and blending, and by adding dopants (including acids and metal oxide nanoparticles).

Multiple polymeric sensing materials were designed, synthesized, and evaluated as a sensing material for ethanol. Both the sensitivity and selectivity of the sensing materials were evaluated. Some of the most promising polymeric sensing materials were then deposited onto two different kinds of sensors: a capacitive radio frequency identification (RFID) sensor and a mass-based microcantilever microelectromechanical systems (MEMS) sensor for further evaluation.

After this wide experimentation, along with what has been reported in the literature, various sensing mechanisms were proposed. These sensing mechanisms explain why certain VOCs sorb more preferentially onto certain polymeric sensing materials. Therefore, identifying the dominant sensing mechanisms for a target analyte can improve sensing material selection.

Based on appropriate sensing mechanisms, potential sensing materials can be chosen for a target analyte. This has led to prescriptions that can be followed when designing a new sensing material for a target application. These prescriptions take into consideration the chemical nature of the target analyte (and thus, the dominant mechanisms by which it is likely to interact), any constraints of the target application (including operational temperature and type of sensor), and the chemical nature of the common interferents present with the target analyte. These prescriptions allow one to narrow down a list of several hundreds of potential sensing materials to a manageable few, which can subsequently be evaluated.