Optical Detection of Hazardous Chemical Vapors Using Monolayer Transition Metal Dichalcogenides

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We previously showed [1] that monolayer transition metal dichalcogenides (TMDs) are sensitive to and selective for vapors of strong electron donors and/or strong electron acceptors in concentrations as low as 1 part per million (ppm) detected by changes in electrical conductance, and that photoluminescence (PL) can also sense such vapors [2]. We show here that the PL intensity of monolayer CVD-grown WS_2 can rapidly (<< 1sec) detect triethylamine (TEA), a decomposition byproduct of the VX series of nerve agents, in concentrations <<1 ppm. The optical response [Fig. 1] is similar to the electrical response of other TMDs [Fig. 2] previously shown [1]. We shall discuss the mechanisms determining the size and shape of the optical and electrical responses. We envision suites of different TMDs using both optical and conductance sensing to rapidly and selectively detect chemical agents, including those used in the Mideast and the explosives used in the Brussels / Paris attacks.

References

[1] AL Friedman et al., Scientific Reports **7** (2017) Art. 3836.
[2] PM Campbell et al., Applied Physics Letters **113** Issue16 (2018) Art.163106.

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Figures

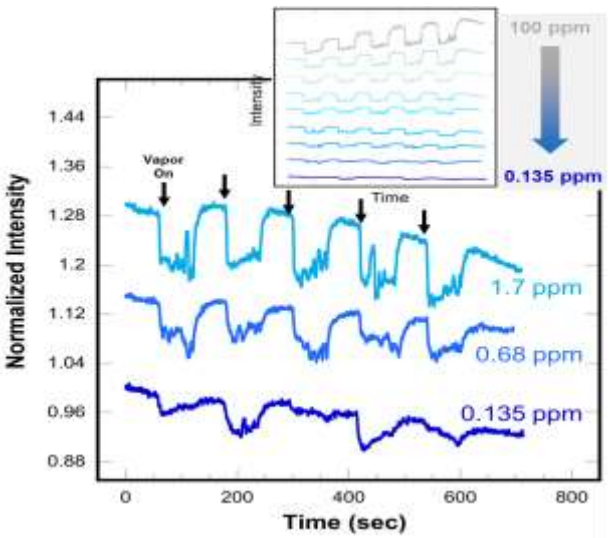

Figure 1: Normalized PL intensity of a monolayer film of WS_2 for various doses of TEA in parts per million (ppm). The PL intensity drops in < 1sec on exposure (arrows indicate "vapour on") and recovers when the vapor exposure stops. WS_2 shows no sensitivity to H_2O vapor and other common atmospheric components. Inset shows full range of measured responses for 100, 50, 25, 13, 7, 3.4, 1.7, 0.68, and 0.135 ppm. Increased noise in the "vapor on" state is due to intermittent jitter in the vapor doser and is not indicative of the intrinsic PL noise level, which is gaug in the "vapour off" state.

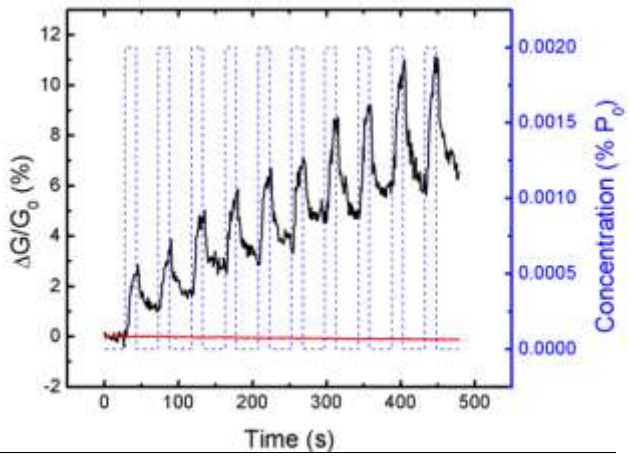

Figure 2: Normalized electrical conductance of a monolayer $MoSe_2$ response to 1 ppm of TEA. Blue lines show on/off vapor pulse sequence. The red line shows null response to saturated water vapor. Note: the conductance response is positive, while the PL response is negative.