PHOSHORENES AS A NEW CLASS OF MATERIALS FOR SURFACE ENHANCED SPECTROSCOPE APPLICATION OR NOT?

Department of Inorganic Chemistry
UCT PRAGUE

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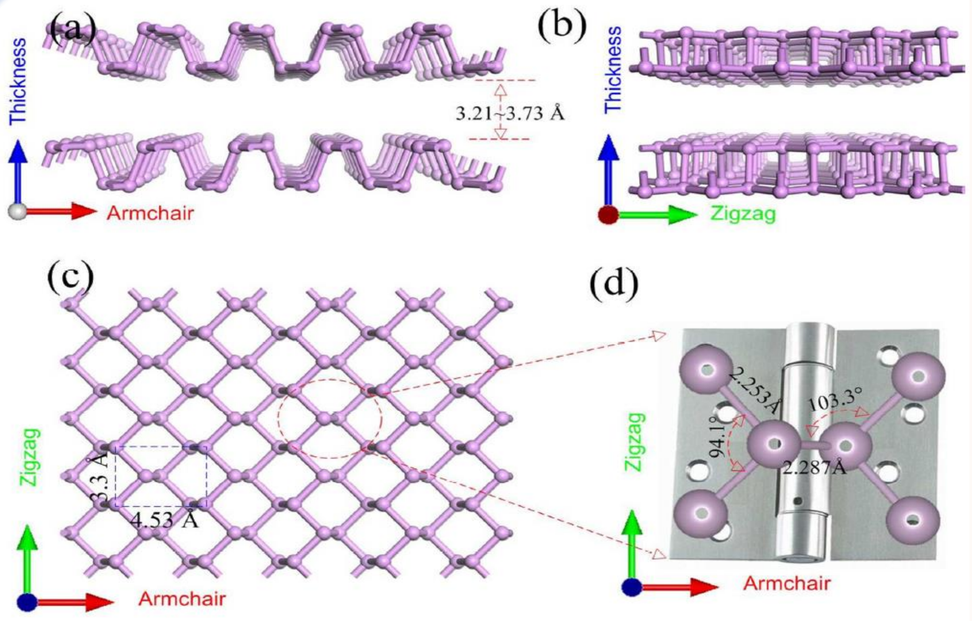
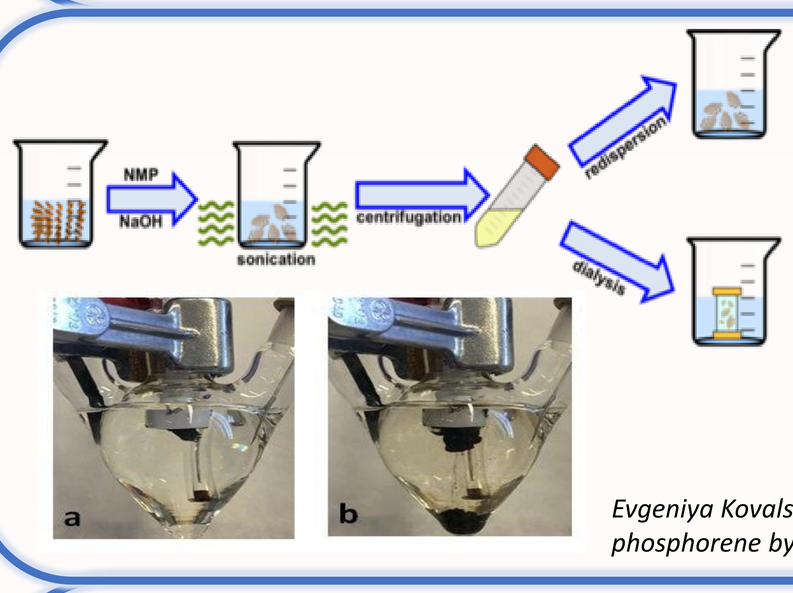
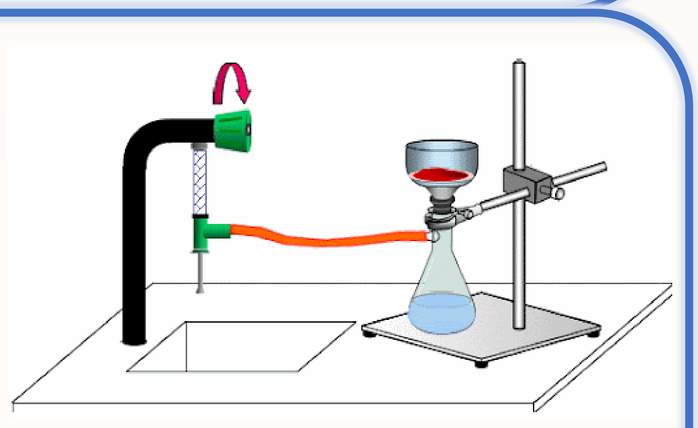


Phosphorene is a two-dimensional material consisting of a single layer of black phosphorus. It is a two-dimensional material in which phosphorus atoms are arranged in layers, arranged vertically in relation to each other. Thin layers of black phosphorus have semiconductor properties, high carrier mobility and a non-zero main band gap.
The band gap of phosphorene can be varied by doping, functionalization, and depending on the number of layers from ~1.5 eV for a monolayer to 0.3 eV for bulk phosphorus.
A phosphorus atom has five electrons in 3p-orbitals and sp3-hybridization.
Each atom has 3 electrons that are covalently bonded to three neighboring phosphorus atoms.
Each "p" orbital has its own lone pair of electrons.
Due to their sp3-hybridization, phosphorene do not have "flat" sheets like graphene, but instead form pleated honeycomb layers held together by weak van der Waals forces.
The distances between the upper and lower atoms (d1= 2.244 Å) and between two neighboring atoms (d2 = 2.224 Å).
Black phosphorus has a rhombic crystal lattice structure.

Liangzhi Kou, Changfeng Chen, and Sean C. Smith. Phosphorene: Fabrication, Properties and Applications. J. ***Phys. Chem. Lett., Just Accepted Manuscript***
DOI: 10.1021/acs.jpclett.5b01094

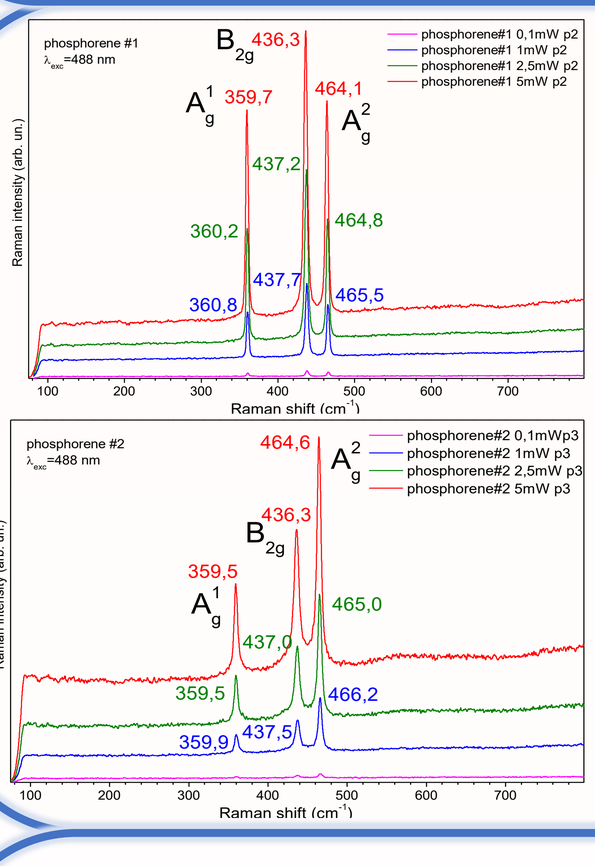


The exfoliation process without the use of surface-active substances allows the creation and transfer of phosphorene-based thin films.
Three-stage low-potential exfoliation was carried out in a pear-shaped electrochemical cell, equipped with four control inputs (0.1 M Ag/AgNO3 in AN), a graphite electrode, a working electrode (black phosphorus crystal), and an outlet for argon removal.



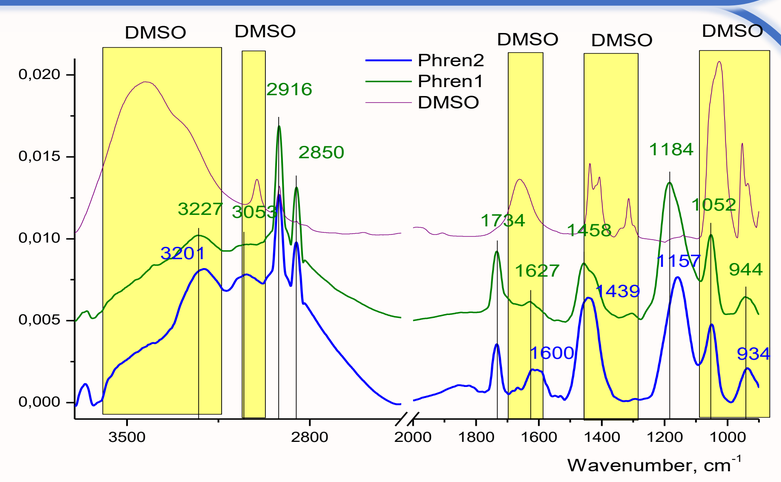
Phosphorene-cleaning system

Evgeniya Kovalska, Jan Luxa, Tomáš Hartman, Nikolas Antonatos, Polina Shaban, Egor Oparin, Maria Zhukova, Zdeněk Sofer. Non-aqueous solution-processed phosphorene by controlled lowpotential electrochemical exfoliation and thin films preparation. ***Nanoscale, 2020, DOI:10.1039/C9NR10257D.***



The Raman spectra of phosphorene with different concentration. Phosphorene 1 = 1.5 mg/ml, Phosphorene 2 = 1.3 mg/ml

In the case of a higher concentration of phosphorene, we observe an unusual distribution of the intensities of the three main modes for multilayer phosphorene A1g, B2g and A2g, strong intensity has a mode B2g. For a sample with a lower concentration, the distribution of intensities and the position of the main modes A1g, B2g and A2g corresponds to a phosphorene sample with a thickness of 3-4 layers.
It can be assumed that phosphorene aggregation processes may occur as the concentration increases.

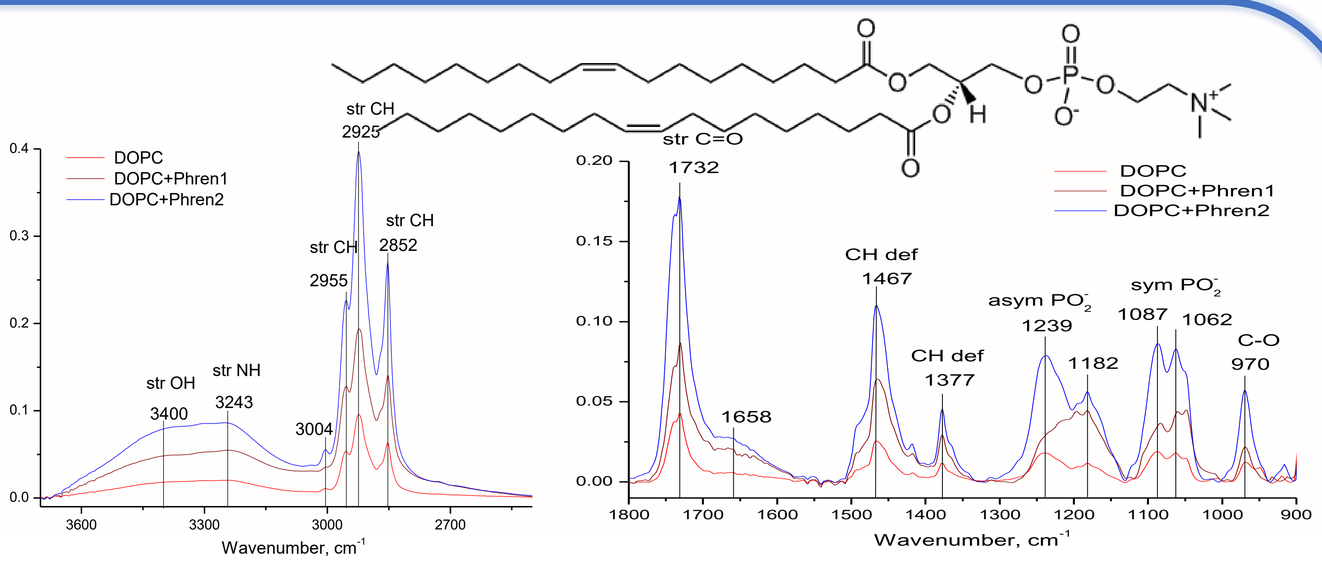


FTIR spectra of phosphorene with different concentration. Phosphorene 1 = 1.5 mg/ml, Phosphorene 2 = 1.3 mg/ml. DMSO absorption regions are marked in yellow.

FTIR spectra of DOPC liposomes and phosphorene with different concentration complexes. Phosphorene 1 = 1.5 mg/ml, Phosphorene 2 = 1.3 mg/ml.

However the experiment with cell membrane indicated it's more strong electromagnetic interaction with 2D-phosphorous, the reason could be a transformation in the structure of interacting surfaces or arising local fields.

We can conclude about strong electromagnetic field caused by 2D-phosphores in the vicinity of very inhomogeneous surface of membrane. Taking into account that the optical signal from membrane is negligible, this technique could be recommended for application of 2D-phosphorene as a SEIRA and SERS substrate.



	OH	NH	CH	CH	CH	C=O	CH def	asym PO_2-	sym PO_2-	C-O
Posphor1	2,7	2,6	2,4	2,2	2,2	2,0	2,5	1,6	1,9	1,8
Posphor2	4,4	4,1	4,2	4,1	4,2	4,1	4,3	4,4	4,5	4,8

Acknowledgement

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