Organic solid-solid wetting: a green chemistry approach to surface engineering of low-dimensional materials

Andrea Greiner de Herrera [a], Frank Trixler [a,b]
[a] *Department of Earth and Environmental Sciences, Ludwig-Maximilians-Universität München, Theresienstr. 41, 80333 Munich, Germany.*
[b] *Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München, Schellingtr. 4, 80799 Munich, Germany.*

trixler@lrz.uni-muenchen.de

Surface engineering of low-dimensional materials via organic semiconductors enables to explore and tap their potential for various areas of applied sciences such as energy conversion, energy storage, or nanoelectronics. However, the insolubility of organic semiconductors is problematic as solution-based approaches for molecular deposition on 2D materials are impossible or require aggressive, toxic solvents. To circumvent this restriction, high demanding deposition techniques or costly chemical modifications to achieve solubility are necessary. Here we show that organic semiconductor monolayer formation on low-dimensional materials is nevertheless possible even in water under ambient conditions – a paradox from the classical perspective of adsorption out of solution. However, shifting towards a nanofluidic perspective resolves this paradox: according to our model, a network of surface-energy related and nanofluid phenomena results in an effect that we term "organic solid-solid wetting deposition" (OSWD) [1]. This effect leads to the adsorption of insoluble organic molecules from dispersed particles. As application examples of OSWD, we show spontaneous coating and self-terminating monolayer formation of organic semiconductors on carbon nanotubes [2] and demonstrate molecular charge-transfer doping of graphene [3], both based on OSWD. Our insight allows to easily circumvent high energy demanding or toxic experimental conditions and is thus substantial for green chemistry approaches to chemical surface engineering and bandgap engineering of 1D and 2D materials.

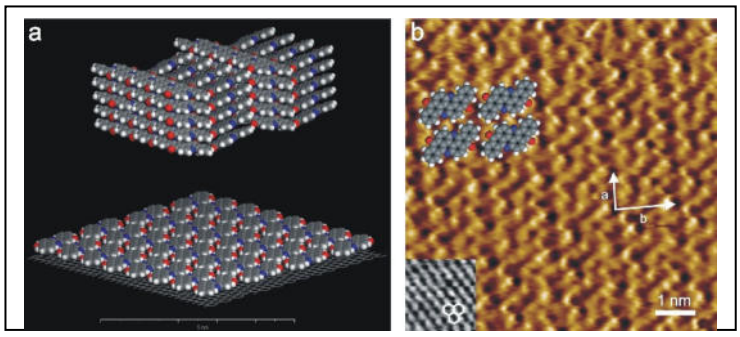

Fig 1. Organic solid-solid wetting of graphene by the organic semiconductor flavanthrone.

a) Force field calculation, b) Scanning Tunnelling Microscopy.

References

[1] A. Eberle, T. Markert, F. Trixler, *JACS* 140, 1327–1336 (2018).
[2] A. Eberle, et. al., *CrystEngComm* 19, 1417-1426 (2017).
[3] A. Greiner de Herrera, T. Markert, F. Trixler, in preparation.

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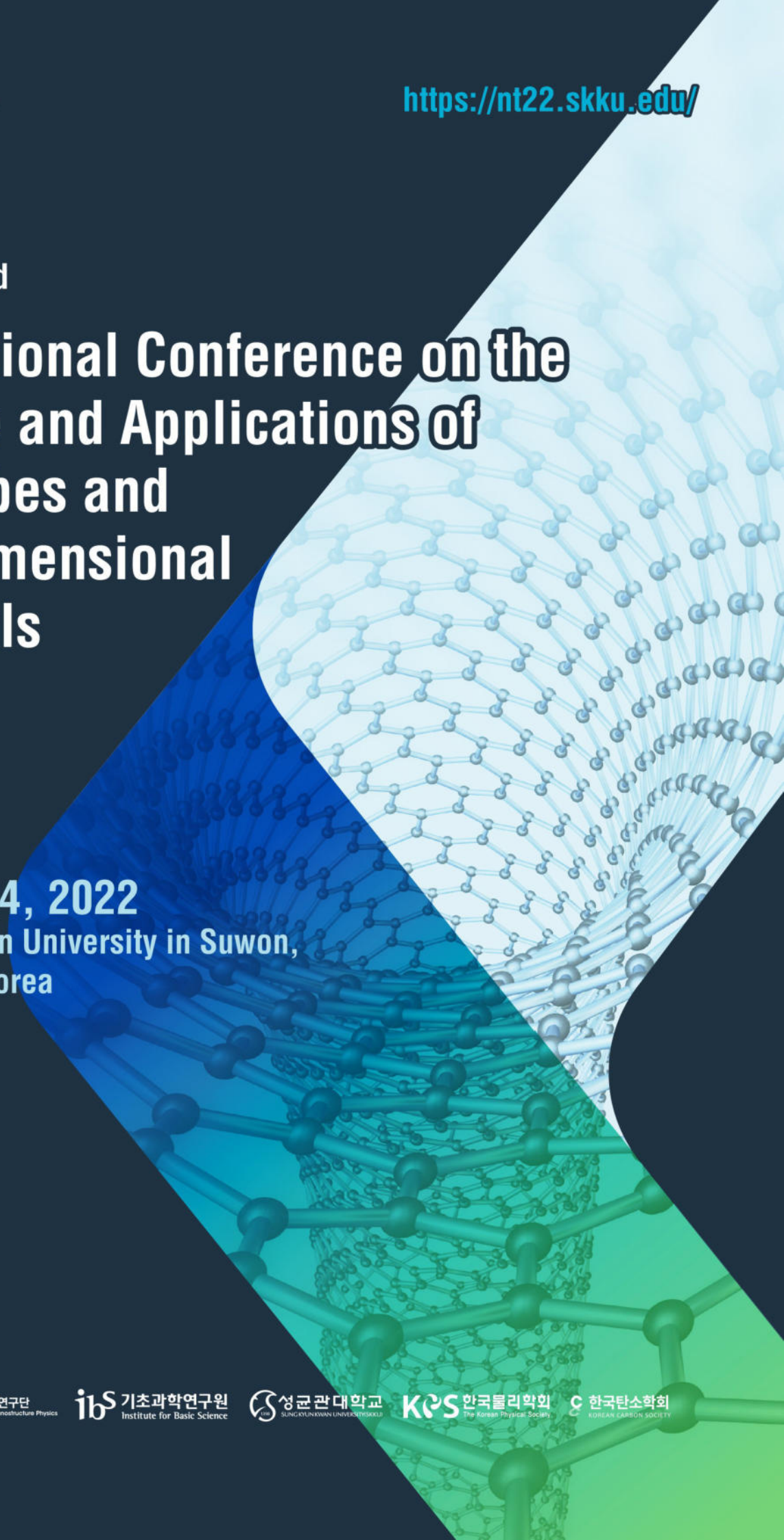

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