Exfoliated Silicate Nanosheets as Novel Near-Infrared Fluorophores for (Bio)Photonics

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Imaging of complex (biological) samples in the near-infrared (NIR) range of the spectrum is beneficial due to reduced light scattering, absorption, phototoxicity and autofluorescence. However, there are only few near-infrared fluorescent materials known and suitable for biomedical applications. Here, we use layered silicates that emit NIR fluorescence (λ_{exc} ≈ 550-650 nm, λ_{emi} ≈ 920-950 nm) with a long excited state lifetime (τ ≈ 10-100 µs): Egyptian Blue ($CaCuSi_4O_{10}$, EB), Han Blue ($BaCuSi_4O_{10}$, HB) and Han Purple ($BaCuSi_2O_6$, HP). Via a mixed approach consisting of milling, tip sonication and centrifugation steps, we exfoliate these silicates into nanosheets (NS) with lateral sizes and thicknesses down to few tenths of nm. The intense NIR fluorescence emission is retained, enabling the employment of these NS as NIR labelling agents. So far, most of our efforts have focused on EB-NS [1], which, compared to standard fluorophores, show no bleaching while displaying outstanding fluorescence intensity. Furthermore, we demonstrated the high potential of EB-NS as NIR fluorophore for bioimaging by *in vivo* single-particle tracking and microrheology measurements in developing Drosophila embryos. Additionally, we have shown that EB-NS can be successfully detected in plants by means of a low cost stand-off detection setup, despite strong plant background fluorescence. EB-NS, HB-NS and HP-NS are also bright enough to be imaged through several cm of tissue phantoms. Additionally, we demonstrate fluorescence lifetime imaging of all the mentioned NS on the microscopic and macroscopic level [2]. In summary, we present a new route to NIR fluorescent nanosheets that promise high potential as novel NIR fluorophores for bioimaging and photonics.

REFERENCES

[1] Selvaggio, G. et al., Nat. Commun., 11 (2020) 1495
[2] Selvaggio, G. et al., in preparation

FIGURES

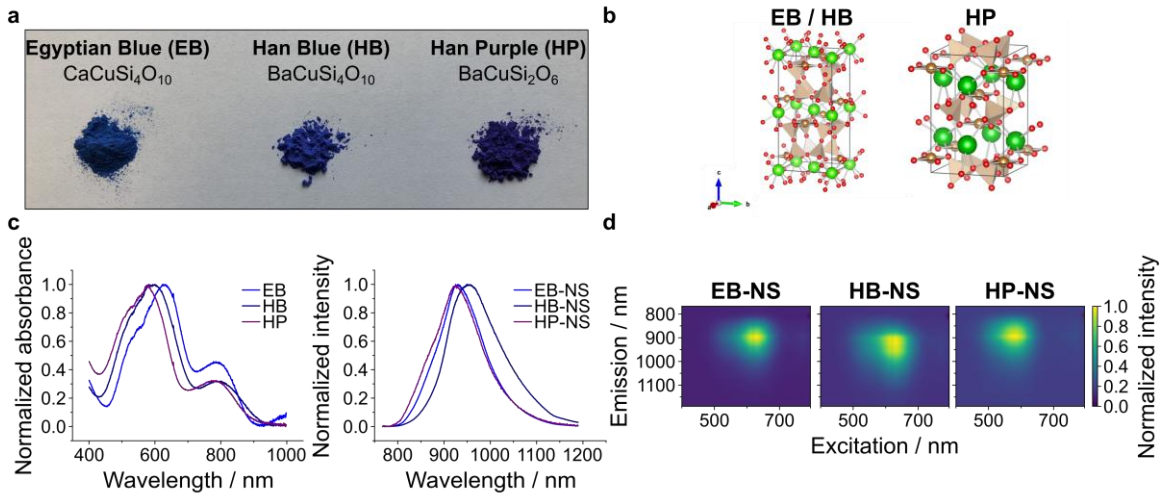

Figure 1: Egyptian Blue (EB), Han Blue (HB) and Han Purple (HP): a family of NIR fluorophores [1]. **a** Picture of bulk, pristine powders of EB, HB and HP. **b** Crystal structures of the three pigments: Si is shown in its typical tetrahedral geometry, Ca (Ba for HB and HP) is depicted as green, Cu as bronze, and O as red spheres. **c** Normalized absorption (reflection) of bulk EB, HB and HP powders, next to 1D fluorescence spectra of EB, HB and HP nanosheets (NS). **d** Normalized 2D excitation-emission spectra of EB-NS, HB-NS and HP-NS.