

Photophysical Interactions of Phthalocyanines with Graphene Nanosheets

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Graphene, an one-atom-thick two-dimensional material, is attracting more and more interest since the pioneering work by Novoselov et al. in 2004.[1] It has outstanding properties like, for example, transparency, high electrical and thermal conductivity, and extreme mechanical strength and elasticity [2], which render it a promising material, for example, for solar cells.[3]

In the current work, a top-down approach to produce graphene flakes, namely liquid phase exfoliation of graphite is used. Hereby, several different phthalocyanines are investigated with regard to their ability to exfoliate graphite, on one hand, and to stabilize as well as to interact with the resulting graphene flakes, on the other hand. Ground and excited state features of these reference systems were probed by means of absorption and fluorescence spectroscopy.

The preparation of stable graphene hybrids followed several enrichment cycles, comprising the addition of natural graphite to a phthalocyanine solution, ultrasonification, and subsequent centrifugation of the suspensions. Hereby, the π - π stacking interactions between the phthalocyanines and the basal plane of graphene stabilize the exfoliated graphene flakes. Raman, TEM, and AFM analyses reveal that the newly formed electron donor-acceptor hybrids coexist upon drop casting as large few-layer graphene and turbostratic exfoliated graphite flakes as well as smaller monolayer graphene. In the resulting hybrids, electronic coupling is seen in the form of newly appearing absorption features and an almost complete quenching of the original phthalocyanine centered fluorescence. The aforementioned was complemented by femtosecond pump probe spectroscopy, which corroborated that the electronic coupling between the phthalocyanines, on one hand, and graphene, on the other hand, is accompanied by ultrafast charge transfer processes.[4-5]

References

- [1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, A. A. Firsov, *Science* (2004) **306**, 666-669.
- [2] K. S. Novoselov, V. I. Fal'ko, L. Colombo, P. R. Gellert, M. G. Schwab, K. Kim, *Nature* (2012) **490**, 192-200.
- [3] M. A. Gluba, D. Amkreutz, G. V. Troppenz, J. Rappich, M. H. Nickel, *Appl. Phys. Lett.* (2013) **103**, 073102.
- [4] R. D. Costa, J. Malig, W. Brenner, N. Jux, D. M. Guldi, *Adv. Mater.* (2013) **25**, 2600-2605.
- [5] J. Malig, D. Jux, D. Kiessling, J.-J. Cid, P. Vázquez, T. Torres, D.M. Guldi, *Angew. Chem.* (2011) **50**, 3561.

Figures

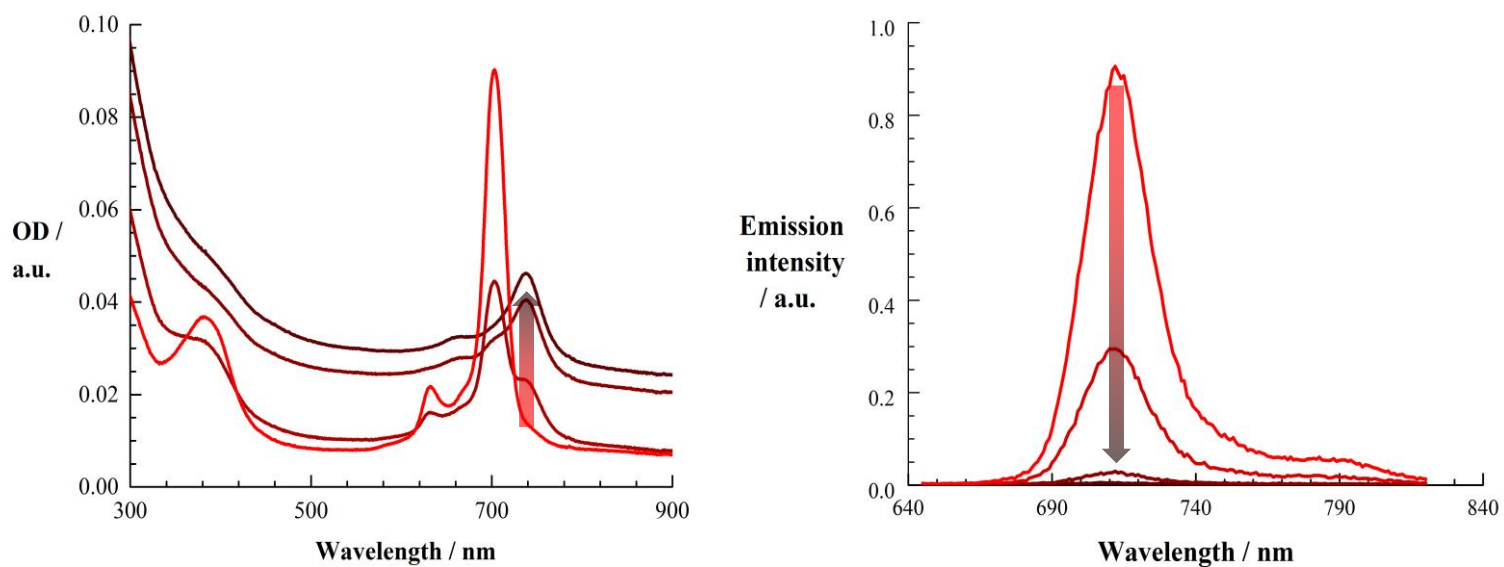


Figure 1: *Electronic coupling between the phthalocyanine and graphene is established by new arising absorption features (left) and a complete quenching of the phthalocyanine centered fluorescence (right) during the enrichment procedure.*