Using Cationic Pyrene Derivatives to Produce Aqueous Graphene Dispersions with Exceptional Stability and Biocompatibility

Yuyoung Shin[1]
Xavier Just-Baringo[1], Sandra Vranic[2], Sai Manoj Gali[3], Alexandra Gkoutzidou[4], Eric Prestat[4,6], David Beljonne[3], Igor Larrosa[1], Kostas Kostarelos[2], Cinzia Casiraghi[1]
[1]*School of Chemistry, University of Manchester, Oxford Road, Manchester, UK*
[2]*Nanomedicine Lab, AV Hill Building, University of Manchester, Manchester, UK*
[3]*Laboratory for Chemistry of Novel Materials, University of Mons, Mons, Belgium*
[4]*School of Materials, University of Manchester, Oxford Road, Manchester, UK*
[5]*SuperSTEM Laboratory, SciTech Daresbury Campus, Daresbury, UK*
Contact@ yuyoung.shin@manchester.ac.uk

Liquid-phase exfoliation (LPE) is a simple, mass-scalable and cost-effective method to produce solution processed graphene [1,2]. A stabiliser must be used to effectively disperse defects-free graphene in water, the solvent, which is abundant, cheap and environmentally friendly and essential for biological applications [3]. Pyrene derivatives, e.g. 1-pyrenesulfonic acid or 1-pyrenecarboxylic acid, have shown high efficiency for exfoliating graphite, compared to other types of stabilisers such as surfactants or polymers [4-6]. However, most of studies shown successful exfoliation with anionic pyrene derivatives. Only few studies have reported the use of cationic pyrene derivatives, and often with low concentration and/or limited dispersion stability [7.8]. Amphoteric pyrene-derivatives were also reported, however with limited stability at neutral pH [9]. In this work we produced and tested various cationic pyrene derivatives as stabilisers for LPE in water. Cationic pyrene derivatives were designed and synthesised with different functional groups and varying carbon linker chain length between the pyrene core and the charged group to get insights on the exfoliation mechanism and to understand how to design the pyrene derivative to achieve efficient exfoliation [10]. Some of the cationic pyrene derivatives were used to produce the graphene dispersions with excellent biocompatibility, cell internalisation capacity, and colloidal stability even in the biological environment, showing great potential of for biomedical applications[10].

REFERENCES

[1] Novoselov, K., et al. Nature, 490, (2012), 192.
[2] Hernandez, Y., et al. Nature Nanotechnology, 3, (2008), 563.
[3] Lotya, M., et al. JACS, 131, (2009), 3611.
[4] Yang, H.,et al., Carbon, 53, (2013), 357-365.
[5] Parviz, D., et al., ACS Nano, 6(10), (2012) 8857-8867.
[6] Schlierf, A., et al. Nanoscale, 5.10 (2013): 4205-4216.
[7] Li, W., et al., Physical Chemistry Chemical Physics, 19(26), (2017), 17036-17043.
[8] Malig, J.,et al., Advanced Materials, 24(6), (2012), 800-805.
[9] Shin, Y. et al. Molecular Systems Design & Engineering (2019). DOI:10.1039/C9ME00024K
[10] Shin, Y. et al. Nanoscale 12 (2020), 12383, DOI: 10.1039/d0nr02689a

FIGURES

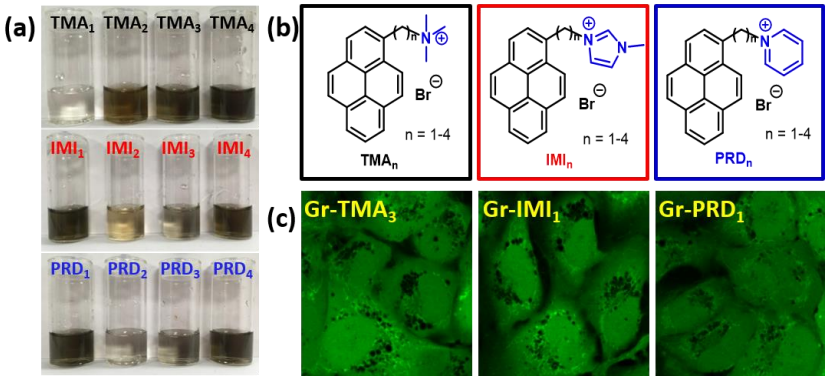

Figure 1: (a) Graphene dispersions prepared with the cationic pyrene derivatives (diluted by factor of 10), (b) structure of cationic pyrene derivatives, and (c) cellular uptake of the graphene nanosheets estimated using confocal microscopy.