

## Polyglycerol-Based Amphiphiles for the Water Solubilization and Aggregate Disruption of Single-Walled Carbon Nanotubes: Structure-Property Relationships

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Carbon nanotubes exhibit numerous properties making them fascinating to study in the laboratory and endowing them with the potential to revolutionize the fields of materials science and nanotechnology.[1] As a material they are, however, difficult to process due to strong self-aggregation that occurs spontaneously in essentially all solution environments. We are interested in semiconducting single walled nanotubes (SWNTs) because of their efficient fluorescence in the near infrared spectral region,[2,3] shared by only a small number of dyes, and the potential medical applications due to the transparency of tissue at those wavelengths. In order to fluoresce, the SWNTs must first be debundled to prevent self-quenching, requiring the use of suitable surfactants.

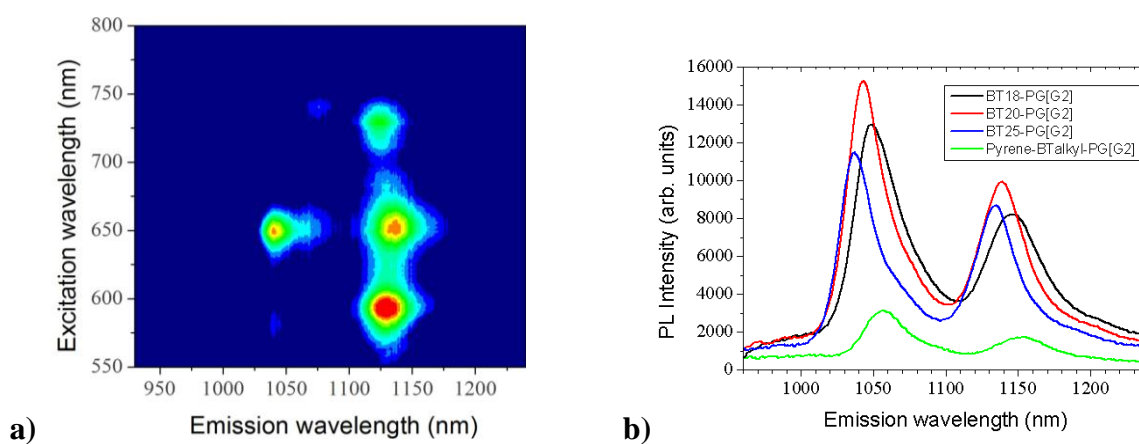
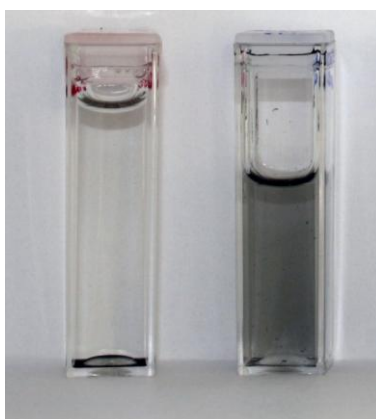
We have developed a series of amphiphiles for the effective solubilization of SWNTs each making use of generation 2 polyglycerol dendrons [4,5] as the hydrophilic head groups (Figure 1). The structure of the hydrophobic tail is then varied to include either hydrocarbon chains of varying lengths or pyrene as anchor groups and varying linking functionalities connecting the hydrophobic groups with the dendrons. When sonicated with SWNTs in water, it was found, quite surprisingly, that the hydrocarbon chain-based amphiphiles gave the best efficiency in SWNT dispersal, as measured both by UV/Vis absorption and near IR fluorescence measurement (Figure 2). Suspensions with these amphiphiles were also stable to re-aggregation over several weeks timescale (Figure 3). Conversely, amphiphiles bearing the commonly-used pyrene anchor group afforded suspensions giving rise to far weaker near IR luminescence and inferior stability. In most cases, the amphiphiles performed more efficiently than common commercial surfactants such as sodium dodecylsulfate and Brij-35.

Among other trends noted was a positive relationship between hydrocarbon chain length and debundling ability. The presence of aromatic spacer groups between the hydrophobic tail and the dendritic head seemed to increase SWNT solubility and debundling ability but decrease the stability of the mixture. Moreover, variation of the aromatic linker groups endowed the amphiphiles with some degree of selectivity over nanotubes of different degrees of chirality, as apparent by near IR luminescent measurements.

### References:

- [1] S. Reich, C. Thomsen and J. Maultsch, *Carbon Nanotubes: Basic Concepts and Physical Properties*, Wiley-VCH (2004).
- [2] L.J. Carlson, T.D. Krauss, *Acc. Chem. Res.* **41** (2007), 235-243.
- [3] M.J. O'Connell, et al. *Science* **297** (2002), 593-596.
- [4] M. Wyszogrodzka, R. Haag, *Chem. Eur. J.* **14** (2008), 9202-9214.

## Figures:

**Figure 1.** Amphiphiles developed for SWNT dispersions in water.**Figure 2.** a) Photoluminescence map showing near IR fluorescence of SWNT dispersion with amphiphile 2. b) Comparison of fluorescence intensity at 650 nm excitation for SWNT dispersions with amphiphiles 1 (red), 2 (black), 3 (blue), and 4 (green curve).**Figure 3.** Comparison of SWNT dispersions with amphiphile 4 (left) and 2 (right) after one week standing.