

Organic Semiconductor Nanoparticle Size Measurement by Asymmetrical Flow Field-Flow Fractionation

General Information

ID0041

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Info	Postnova AF2000, PN3211 UV/Vis
Keywords	Asymmetrical Flow Field-Flow Fractionation, Semiconductor, Organic Nanoparticles, Nanotechnology

Introduction

Organic nanoparticles (NPs) are touted as a material of the future for semiconductor applications [1]. Their advantages over traditional semiconductors are chiefly due to the fact that metals are not needed; this makes organic NPs less toxic, more biodegradable, and less harmful to the environment with no need for metal mining. Characterization of organic NPs is important, as particle size will impact the material's band gap and therefore semiconductor performance [2]. In order to provide high enough resolution to detect minute differences in size distributions, appropriate analytical techniques must be used for these materials. In this Application Note, we present data on size characterization of three organic NPs with slightly different size distributions using Asymmetrical Flow Field-Flow Fractionation (AF4) coupled to UV/Vis detection. A schematic for the AF4 channel is shown in Figure 1. The combination of cross flow and channel flow causes size separation over the course of the analysis, with smaller particles eluting to connected detectors before larger particles.

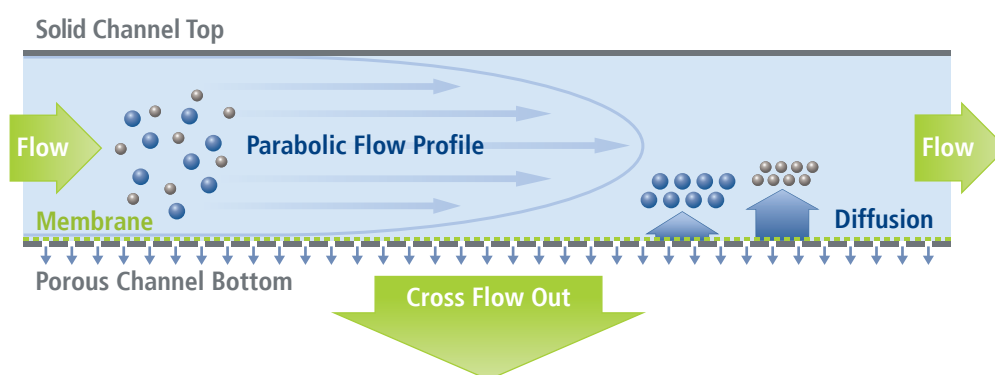


Figure 1: Schematic of the AF4 separation principle.

Experimental Details

The composition of the organic NPs used in this study is confidential. To separate by size and characterize them, an AF4 system (Postnova AF2000) was used with an in-line UV/Vis detector (PN3211). An AF4 carrier solution of 20 mM HEPES, 0.1 % Pluronic F68, at pH = 8.0, was used in the experiments. A calibration curve using 6 gold NP standards (British BioCell International) of 5 nm, 10 nm, 15 nm, 20 nm, 30 nm, and 100 nm diameter was used (Figure 2) to relate retention time to hydrodynamic diameter and generate size distributions (Figure 4).

Results

The UV/Vis response for the organic NP samples is shown in Figure 3 as the three traces. The sizes of the three samples are very similar, so there is virtually no resolution between the peaks. However, there is a small but visible difference in retention time between sample 1 and samples 2 and 3.

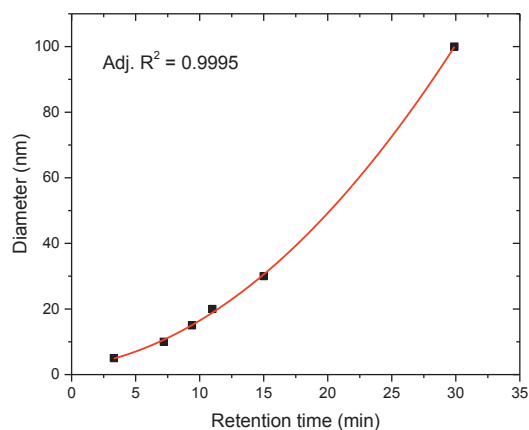


Figure 2: Calibration curve using 6 gold NP standards to relate retention time to hydrodynamic diameter.

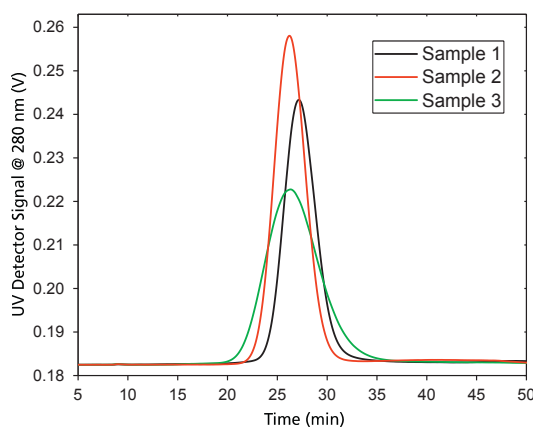


Figure 3: Fractograms for the three NP samples by AF4-UV/Vis analysis.

Figure 4 shows the hydrodynamic diameter distributions for the three organic NP samples used in this study, as calculated from the calibration data shown in Figure 2. Using this approach, we can discern small differences in particle size distributions between the three NP samples. There is a small but clear difference in the mode size for sample 1; the hydrodynamic diameter at peak max (56 nm) is slightly bigger than samples 2 and 3. Samples 2 and 3 have very similar diameters at peak maxima (51 and 50 nm respectively), but we can observe from Figure 4 that sample 2 has a slightly wider size distribution, with particles smaller and larger than those in sample 3. The differences observed in these distributions are subtle, but they can potentially have a major effect on semiconductor material properties.

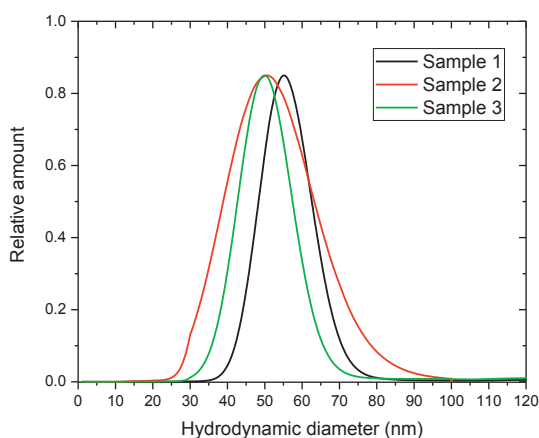


Figure 4: Hydrodynamic diameter distributions, determined from Au standard NP calibration curve, for the three organic NP samples.

Conclusion

From the data presented here, we see that AF4 can separate small but potentially important differences in size for organic NPs. The very small differences in size between these samples would make lower-resolution measurements such as dynamic light scattering or batch MALS unable to discern any differences in size; however, separation by AF4 enables this higher-resolution analysis.

References

- [1] G. P. Neupane, W. Ma, T. Yildirim, Y. Tang, L. Zhang, Y. Lu. Nano Materials Science, 2019, 1 (4), 246-259.
- [2] S. Baskoutas, A. F. Terzis, Journal of Applied Physics, 2006, 99 (1), 013708.