Graphene and Graphene Oxide – Characterization of Unique Carbon Modifications Using Asymmetrical Flow Field-Flow Fractionation

General Information

ID0030

Application	Electronic Engineering, Display Technology, Nanotechnology
Technology	Asymmetrical Flow Field-Flow Fractionation, Multi-Angle Light Scattering
Info	AF2000 AF4, PN3621 MALS, PN3211 UV
Keywords	Graphene, Graphene Oxide, Carbon, Planar Macromolecule, Fractal Dimension

Introduction

Graphene is a planar modification of pure carbon: independent sp^2 hybrid carbon atoms form a two dimensional network with a hexagonal honeycomb crystal structure. Graphene oxide has also a single atomic layer but compared to graphene there are many oxygen-containing functional groups on the graphene oxide sheet layer. [1] The family of graphene nanomaterials has shown great potential for a multitude of technological applications in different fields. Graphene is the best conductor of electricity known. Another notable property of graphene is its unique levels of light absorption. Graphene can be used to expand the capacity and charge rate of batteries and as a promising material in electronic engineering where researchers try to create supercapacitors out of graphene. Furthermore, graphene can be used in touchscreens, Smart Windows, flexible OLED/LCD displays and solar cells. [2, 3] The water soluble derivative of graphene, graphene oxide, has the advantages of low production costs, larg scale production and easy processing. Due to its unique mechanical, electronical and chemical properties it attracts the attention of the entire scientific community. [1, 4] For example it is used in the field of nanomedicine or environment. [5, 6]

To survey synthesis strategies or to monitor graphene or graphene oxide in various samples it is essential to characterize them according to their size and shape. The Postnova AF2000 Asymmetrical Flow Field-Flow Fractionation (AF4) system hyphenated with the PN3621 21-angle Multi-Angle Light Scattering (MALS) and the PN3211 UV detection is a precise analytical tool for the separation and characterization of graphene and graphene oxide samples.

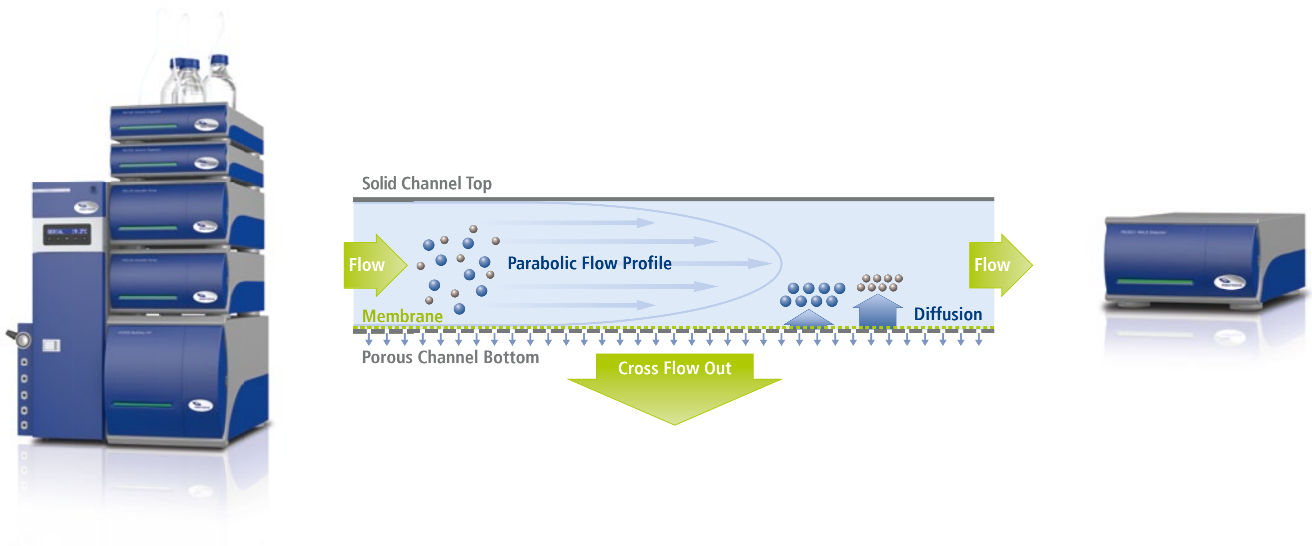

Figure 1: Left - AF2000 AF4 System, Middle - Principle of AF4, Right - PN3621 MALS.

Field-Flow Fractionation (FFF) is a flow based separation technique, where fractionation takes place in a thin ribbon-like channel without stationary phase. Separation along the channel length is achieved by the interaction of sample constituents with an external force field perpendicular to the laminar channel flow, in AF4 this is a second flow (cross flow). The smaller the particles are the higher is their diffusion coefficient and the better they can migrate against the cross flow. Due to the laminar flow profile of the channel flow with increasing flow velocity from the bottom up to the middle of the channel, particles with higher diffusion coefficients reaches faster flow lines and elutes first.

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Experimental and Results

The graphene samples were synthesized by Universidad de Córdoba via exfoliation of micrographite (Nanostructured & Amorphous Materials Inc. (Katy, TX, USA)) using an ultrasound probe [7]. The samples were dispersed in pure water (1 mg/mL). Furthermore a commercially available single layer graphene oxide dispersion (ACSmaterial, CA, USA) was investigated after dilution in DI water (1 mg/mL).
Both measurements took place in an AF4 channel equipped with a RC 10 kDa membrane. Pure water for the graphene samples and 0.05 % NovaChem for the graphene oxide samples were used as eluents.

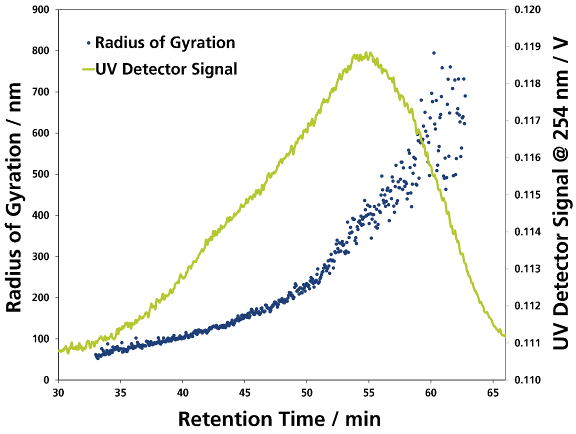

Figure 2: Overlay of Radius of Gyration and UV detector signal vs time for graphene sample.

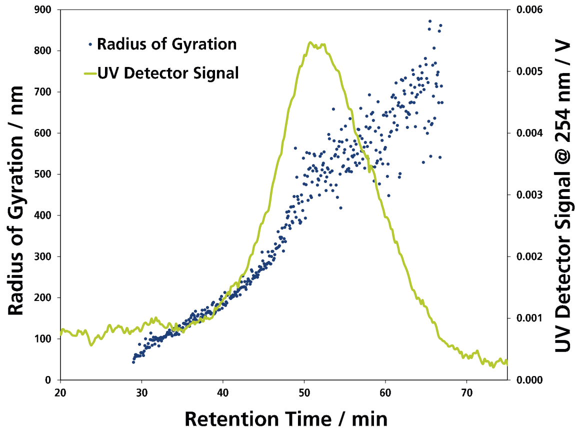

Figure 3: Overlay of Radius of Gyration and UV detector signal vs time for graphene oxide sample.

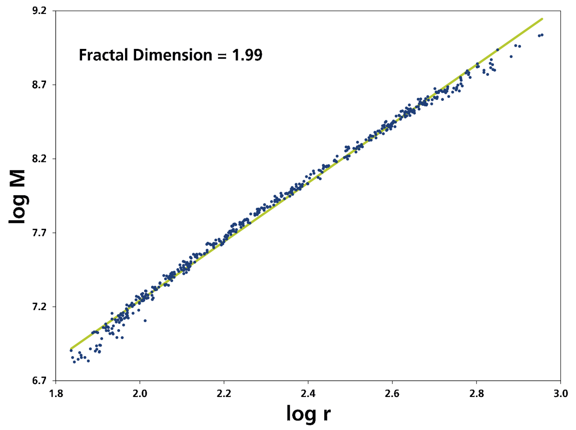

Figure 4: Fractal Dimension analysis: log-log plot of Radius vs Molar Mass for graphene.

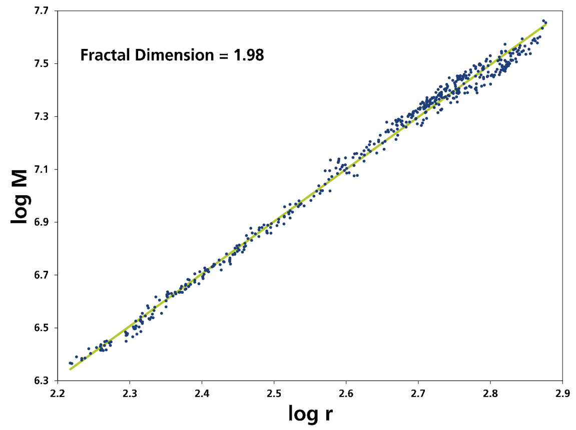

Figure 5: Fractal Dimension analysis: log-log plot of Radius vs Molar Mass for graphene oxide.

The particle sizes derived from MALS reaches from a radius of gyration of 60 nm up to about 700 nm. Calculations are based on a Random Coil Fit. UV detection, which works as concentration detection, shows, that in the graphene sample the proportion of small particles is significantly higher than in the graphene oxide sample. A logarithmic plot of Radius vs Molar Mass, calculated by MALS and UV detector signal, illustrates that the fractal dimension of all particles is, as expected, about 2 in both samples, which is the value of an idealized flat surface [7, 8].

Conclusion

Asymmetrical Flow Field-Flow Fractionation can separate graphene and graphene oxide samples according to their hydrodynamic size. Multi-Angle Static Light Scattering is able to measure the size (radius of gyration) of the graphene samples. Via calculating the fractal dimension the shape of the flat graphene and graphene oxide molecules can be confirmed.

References

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