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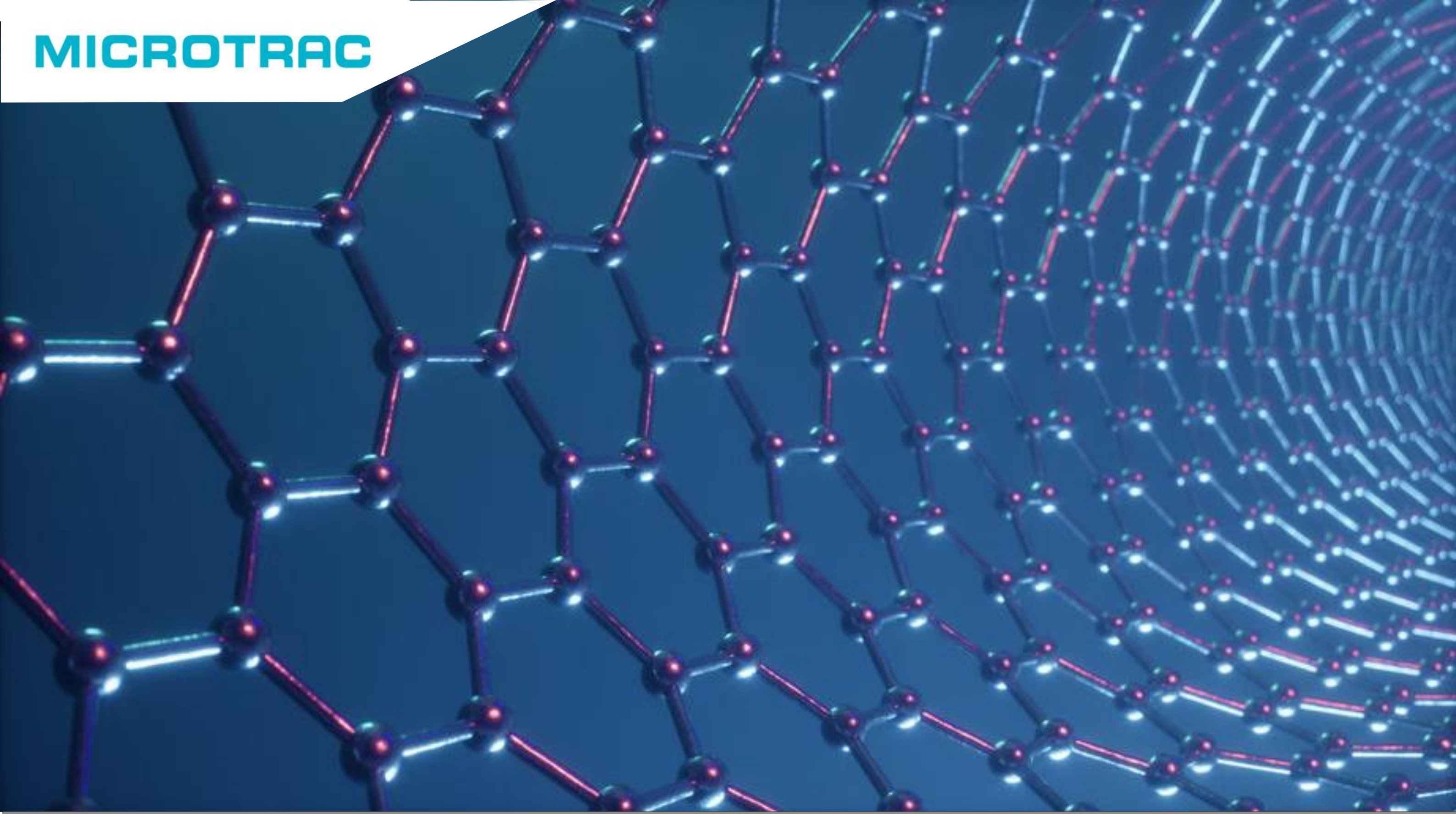


GRAPHENE OXIDES DISPERSIONS

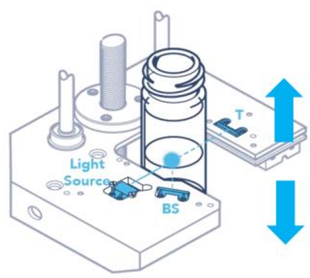
OPTIMIZING THE DISPERSION OF FUNCTIONALIZED GRAPHENES IN DIFFERENT SOLVENTS

Context

Graphene has come into the spotlight in nanoscience and nanotechnology since it was discovered in 2004. Its unique nanostructure and extraordinary mechanical, electrical, and optical properties hold great promise for potential applications in many technological fields. Consequently, many progresses were made to provide commercial access to a large area of products. Nevertheless, because of the cohesion energy between the 2D layer of molecules, the use of graphene in a dispersed phase is still very challenging as it is difficult to assure homogeneity in most organic solvents and water. Recently, several efforts have been made to modify graphene with various methods to overcome this issue. In this study extracted from the literature, the dispersion of graphene oxide and its derivatives was analyzed in different types of solvents to demonstrate the advantage of using the TSI (TURBISCAN Stability Index) to quantify and rank solvent efficiency in dispersing these oxides.

TURBISCAN: How it works

TURBISCAN technology, based on Static Multiple Light Scattering, consists on sending a light source (880 nm) on a sample and acquiring backscattered (BS) and transmitted (T) signal all over the height of a sample. By repeating this measurement over time at adapted frequency, the instrument enables to monitor physical stability.The signal is directly linked to the particle concentration (φ) and size (d) according to the Mie theory:



BS and T = f(φ, d, np, nf)

Method

To evaluate the dispersibility of graphene oxide and its derivatives, graphene oxide and its derivative powders (Graphene oxide (**GO**), reduced graphene oxide (**rGO**), Ethylene Glycol-modified graphene oxide (**EG-rGO**), Graphene oxide with carboxyl groups (**COOH-GO**) were dispersed at a concentration of 0.1mg/L into 21 organics solvent classified in 3 categories: non-polar, polar protic and polar aprotic. Samples were analyzed using the TURBISCAN technology at 30°C.

Results

Raw data

The transmission signal for sample scanned along whole sample height over time are presented on Figure 1.

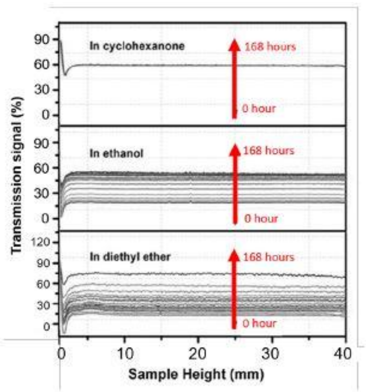


Figure 1: Transmission intensity variation of rGO in three different solvents

Figure 1 shows that for rGO solvents prepared in diethyl ether and ethanol, transmission signal increases. In contrast, the transmission signal of rGO in cyclohexanone has no discernible change with time.
These results show that the dispersion of rGO in cyclohexanone is more stable than in ethanol and diethyl ether.

Stability quantification with the TSI

In order to measure the capability of the graphene to be dispersed in different solvents, the global stability index (TSI) of the sample was computed automatically from the TURBISCAN software. The TURBISCAN Stability Index (TSI) sums all variations TURBISCAN detected in the sample (sedimentation, clarification, size variation). At a given ageing time, the higher is the TSI, the worse is the stability.

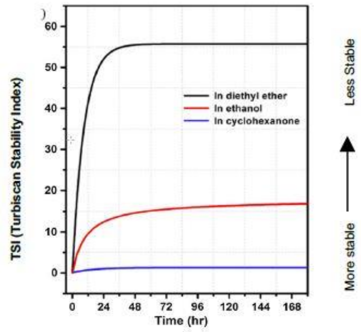


Figure 2: TSI versus time for rGO in the three different solvents

Figure 2 showing the TSI versus time for sample rGO allows to confirm the observation as seen with figure 1 - rGO in cyclohexanone is more stable than in ethanol and diethyl ether. However, it provides a quantitative information on the destabilization over time. As for all solvents the TSI values reach a plateau after 24 hours, no significant destabilization is observed after this time. Also, it is possible to notice that only 12 hours and even 6 hours of measurement are enough to compare the stability of the samples.

Optimization of graphene dispersions

From the TSI kinetics, the values at 24 hours of measurements are reported for each graphene in all the solvents in a radar chart presented in the fig. 3.

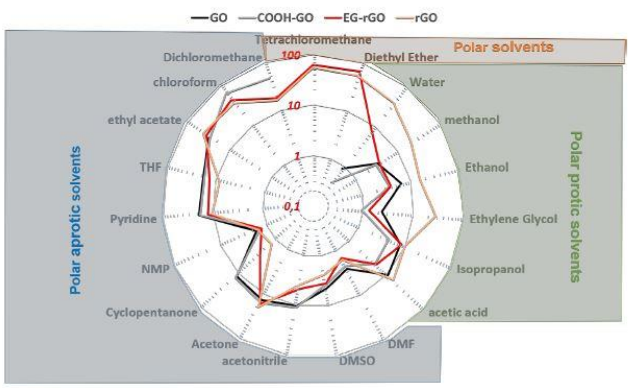


Figure 3. TSI for graphene derivatives in the different solvents

The radar shows that the closer the TSI values are to the center, the higher the stability in the solvent. The correlation between TSI values and visual observation mentioned in the publication tends to evaluate that acceptable conditions are met when TSI<2 for the same comparison time. Thank to graphic visualization it can be concluded that the graphene derivative rGO is unstable in the protic solvents and all samples are unstble in polar aprotic solvents. Figure 4 gives a closer view in the range of TSI between 0 and 2.

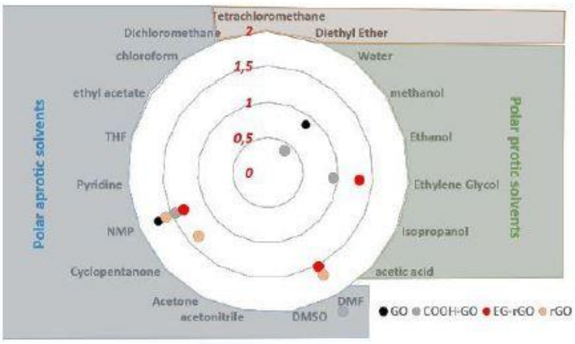


Figure 4. TSI between 0 and 2 for all the graphene in solvents

NMP is the only solvent able to disperse well all the graphene derivatives, but this study permits to qualify efficiency of other solvents to find alternatives to NMP, for example water for COOH GO and GO, Ethylene glycol for EG-rGO and cyclopentanone for rGO.

Conclusion

TURBISCAN offers a quick and easy method to qualify the efficiency of solvents to disperse graphene oxide and derivatives. Measurements were done for 7 days but after few hours only it was possible to rank the sample stability.

References

J. Dai, G. Wang, et al. « Study on the surface energies and dispersibility of graphene oxide and its derivatives » *J Mater Sci* 50 (2015): 3895-3907.