GraphendO graphene hydroxide: a new leaf on the graphene tree

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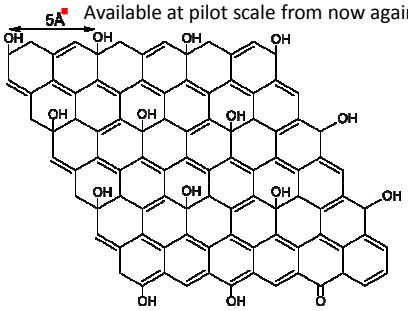
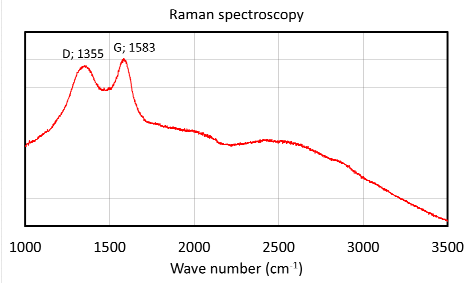
Graphene Hydroxide

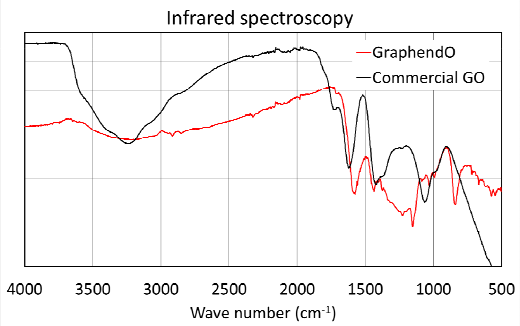
- GraphendO™ graphene hydroxide is synthesized from commonly available chemicals in a bottom-up procedure
- No natural graphite is used as a raw material
- Environmental benefits → no acid waste as residue
- Due to the synthesis method, the material is presumably primarily hydroxyl-functionalized in a relatively low concentration
- Available at pilot scale from now against competitive price.



Example of how a structure could look like. Degree of hydroxylation varies with location and synthesis conditions. We believe that all hydroxyl groups are on the same side of the sheet (so sheets have a hydrophilic and a hydrophobic side), but this hypothesis needs to be verified.

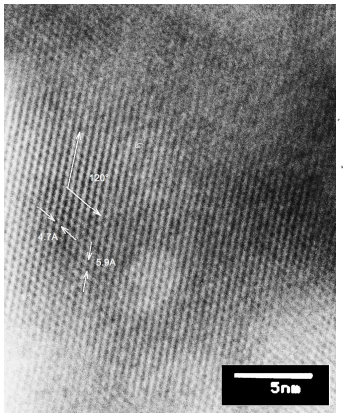
Spectroscopy

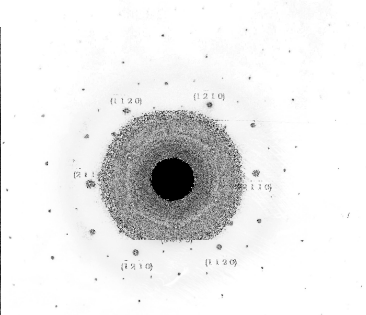




Commercial GO was synthesized via Hummer's method

Electron microscopy



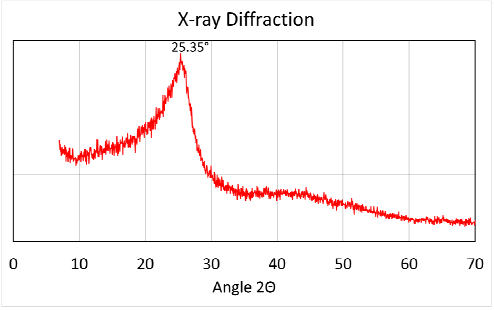


Typical electron diffraction pattern, proving that there is order in the structure.
Other locations give other diffraction patterns, and some areas are not ordered.
TEM gives evidence of (wrinkled) single sheets.

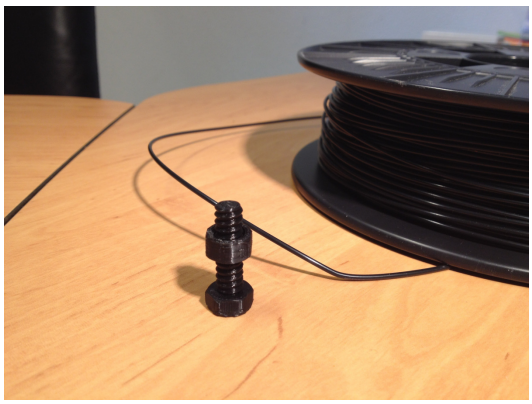
Polymer reinforcement

	Elongation at Break (%)		Modulus [mN/tex]		Force at Break [N]	
	mean	sd	mean	sd	mean	sd
PLA+nano-material 0,2 %	3.4	0.3	47.1	0.8	139	2
PLA blank	3.7	0.6	43.8	1.4	126	4

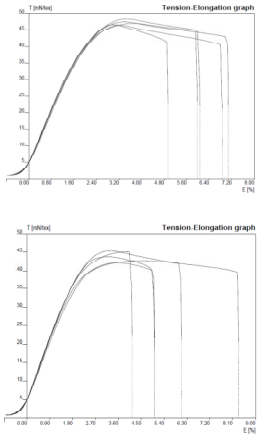
X-ray diffraction



Peak position is at slightly lower angle than for pure graphite. Other graphene derivatives produced under different synthesis conditions give a peak at lower angle, probably due to a higher degree of hydration resulting in larger sheet spacings.



"GOPLA" is a PLA 3D print material with GHO and another nanomaterial. It proved that Graphendo's GHO is easy to blend.



GOPLA (top) vs PLA

Conclusions

- It is possible to synthesize graphene (hydr)oxide in a one step procedure, potentially resulting in nano material at low cost in an environmentally benign process.
- Bio-based Graphene Hydroxide is possible as the monomer could also be bio-based.
- No reinforcement was found in epoxy resins (0.5% w/w), but the modulus of PLA could be enhanced with 10 % in presence of another nanomaterial (both materials at 0.1 % w/w).

- Acknowledgment: Jan Jager, Stenden Hogeschool, Emmen, NL, for making the GOPLA fiber.