COLLOIDAL AND CHEMICAL PROPERTIES OF GRAPHENE OXIDE AND STEP WISELY REDUCED GRAPHENE OXIDE

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Carbon based materials

- Graphite
- Graphene and Graphene based material
- Carbon nanotube (single wall and multiwall)
- Fullerene (C60 & C540)
- Diamond
- Amorphous carbon

- High surface area
- High electronic Conductivity
- High young's modulus and exceptional mechanical properties
- High thermal conductivity
- High optical transmittance
- Its potential for wide range applications

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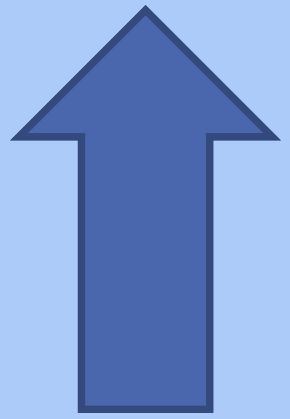
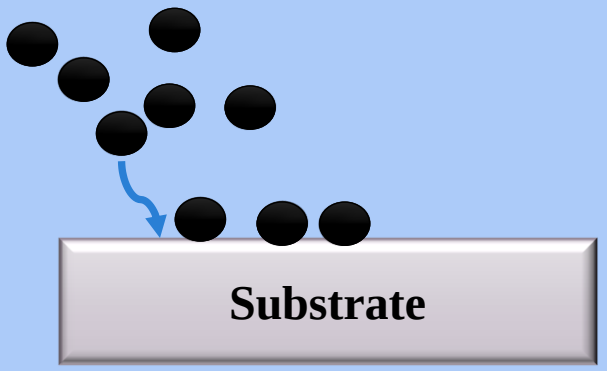
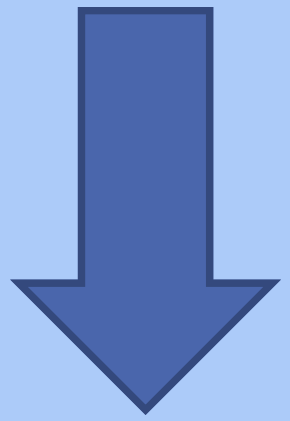
Synthesis of Graphene



Bottom Up-

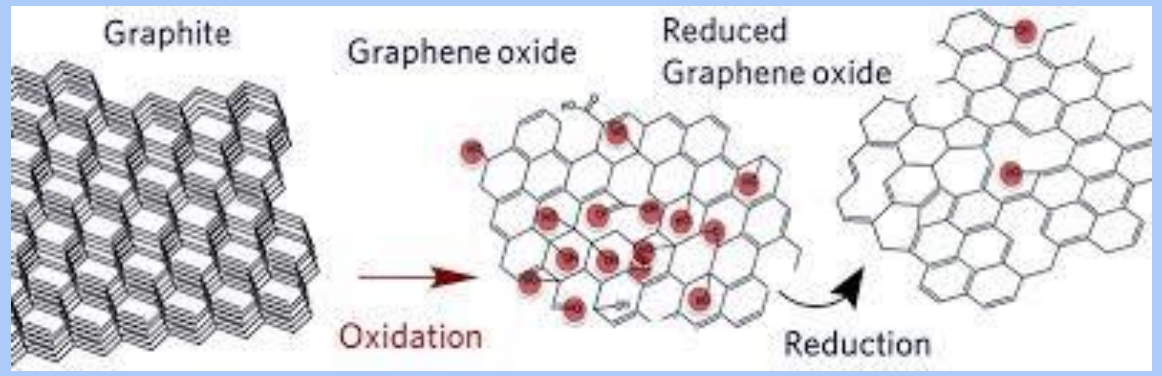
Chemical Vapor Deposition





Top Down-

Exfoliation of Graphite Oxide



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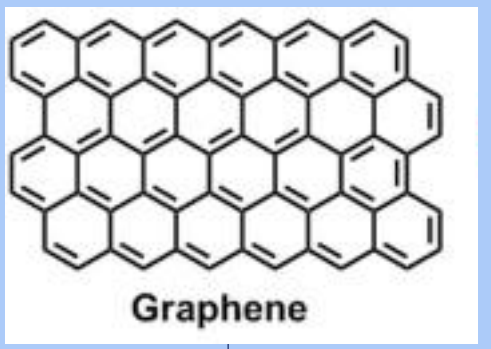
https://www.cheaptubes.com/reduced-graphene-oxide-structure/

Why Controlled reduction important?

Graphene oxide

High dispersibility in hydrophilic solvents

Can be synthesized in large quantities from inexpensive graphite

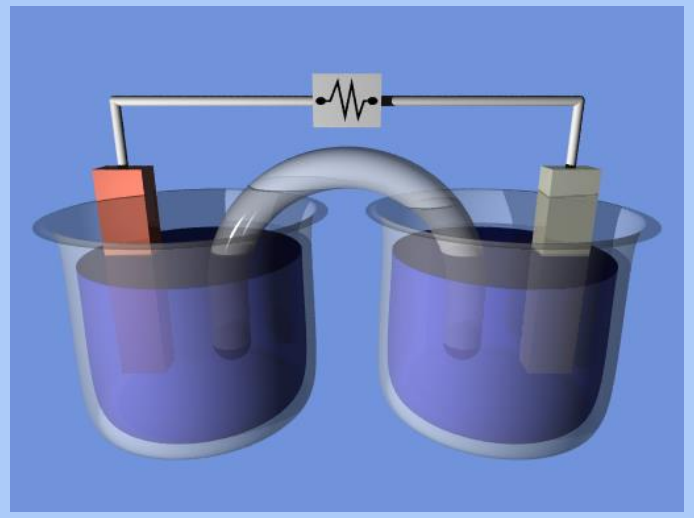

Graphene

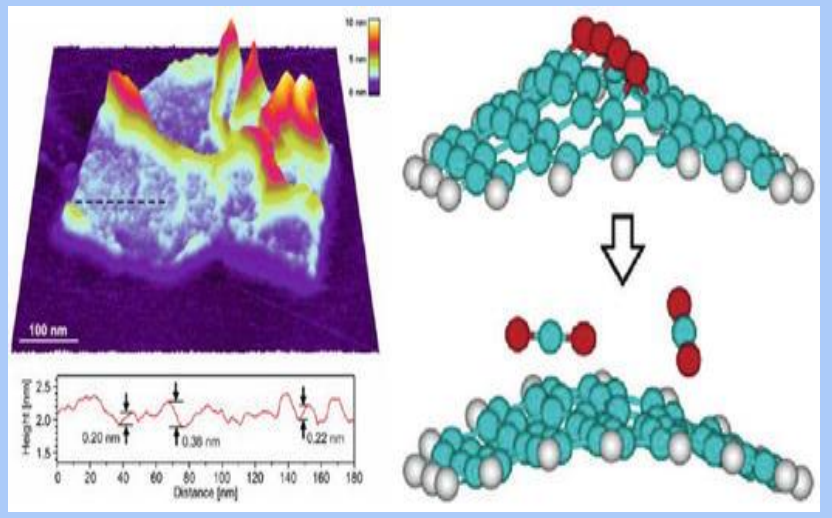
Excellent and thermal condelectrical uctivity

High mechanical strength

- There is a gap in the literature on the direct comparison on properties of GO and different oxygen level in r-GOs.

Synthesis of Reduced graphene Oxide





Electrochemical Reduction

Thermal Reduction

Chemical Reduction

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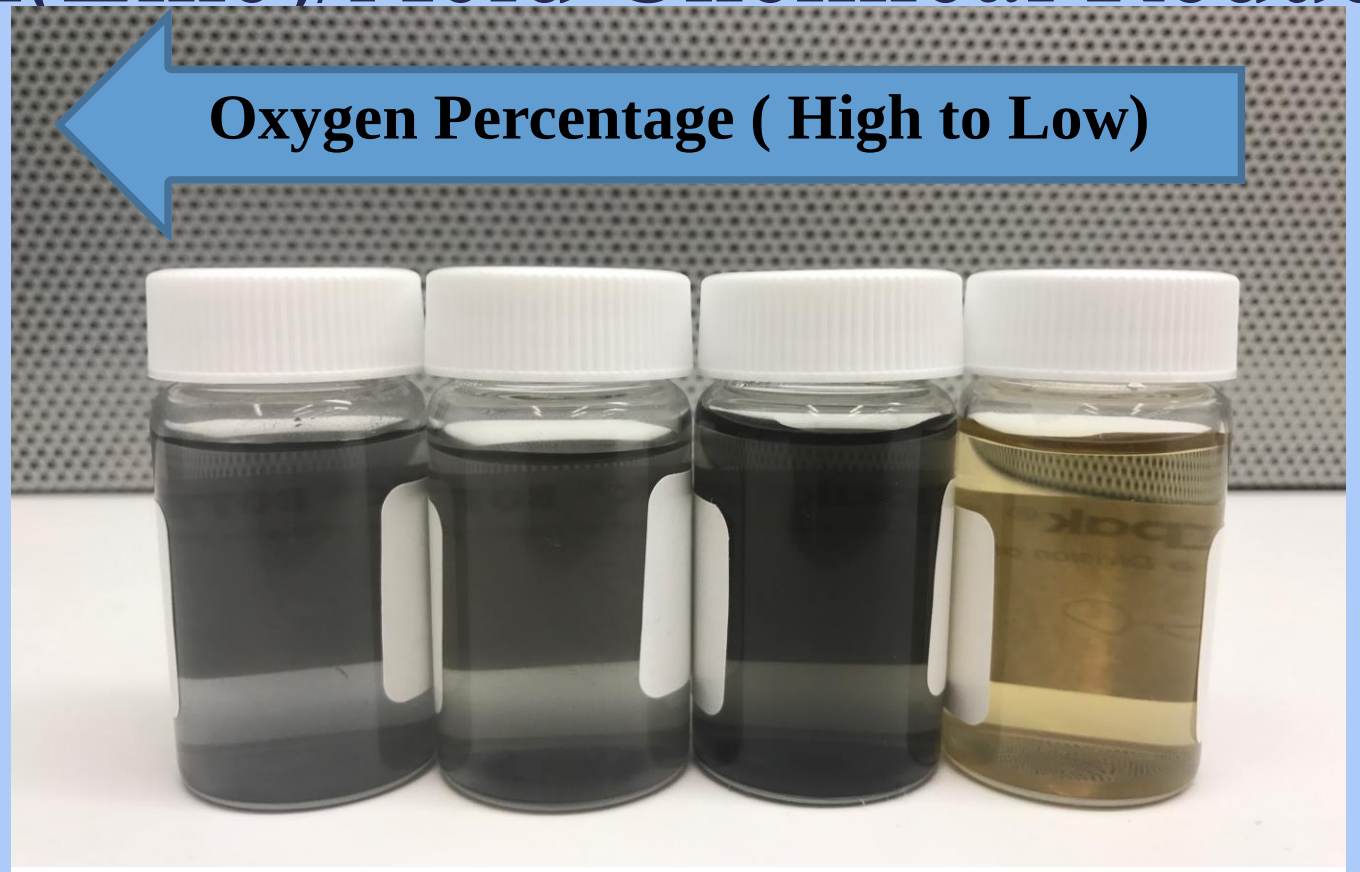
https://www.intechopen.com/books/graphene-materials-advanced-applications/chemical-thermal-and-light-driven-reduction-of-graphene-oxide-approach-to-obtain-graphene-and-its-fu
https://en.wikipedia.org/wiki/Electrochemical_cell#/media/File:ElectrochemCell.png

Stepwise Reduction of GO by Metal(Zinc)/Acid Chemical Reduction



$$Zn \longrightarrow Zn^{2+} + 2e^{-} \text{ and}$$

$$GO + aH^{+} + be^{-} \longrightarrow rGO \cdot cH_2O$$

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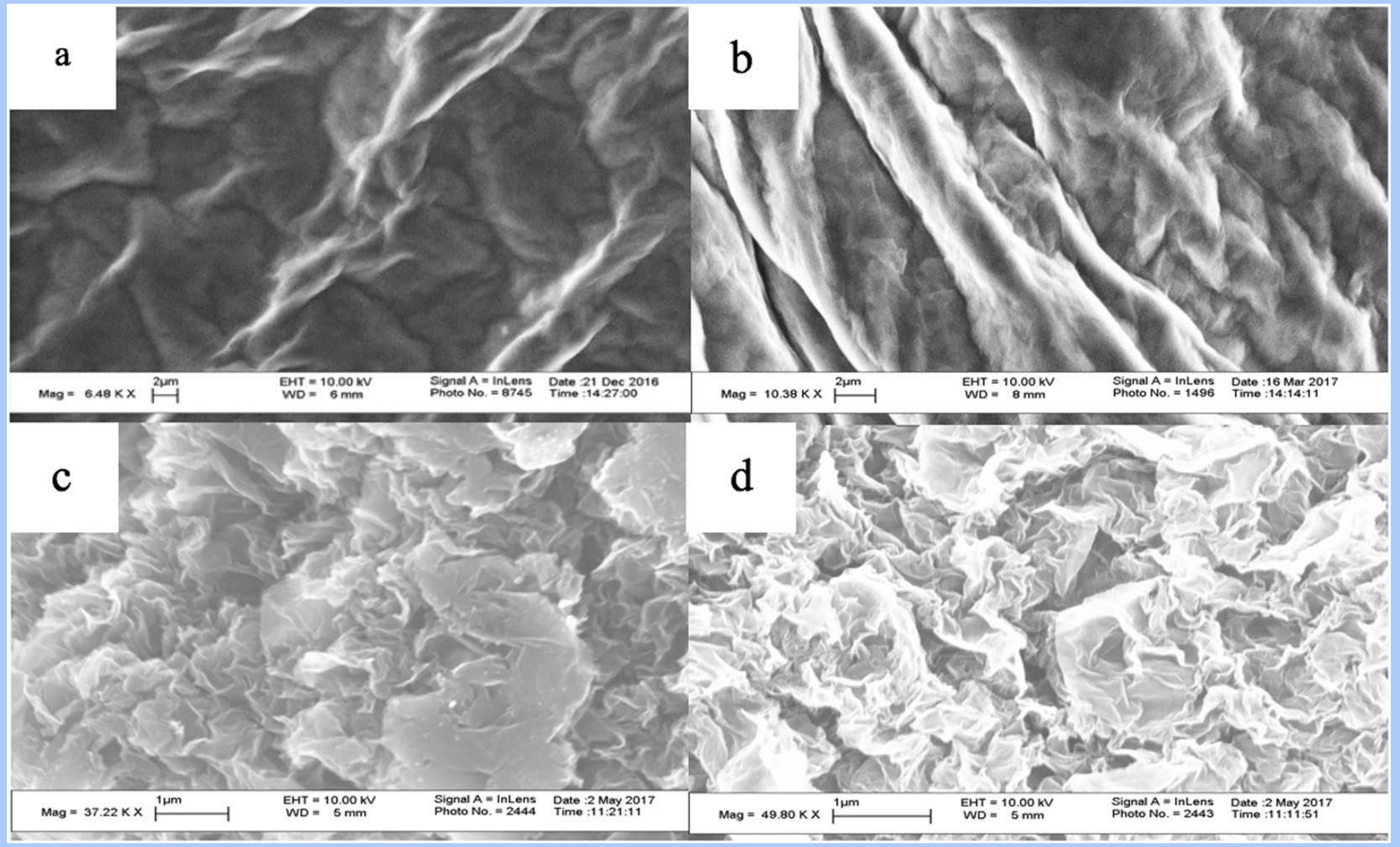
SEM (Scanning Electron Microscope)

a) Graphene Oxide
b) r-GO-31
c) r-GO-19
d) r-GO-9



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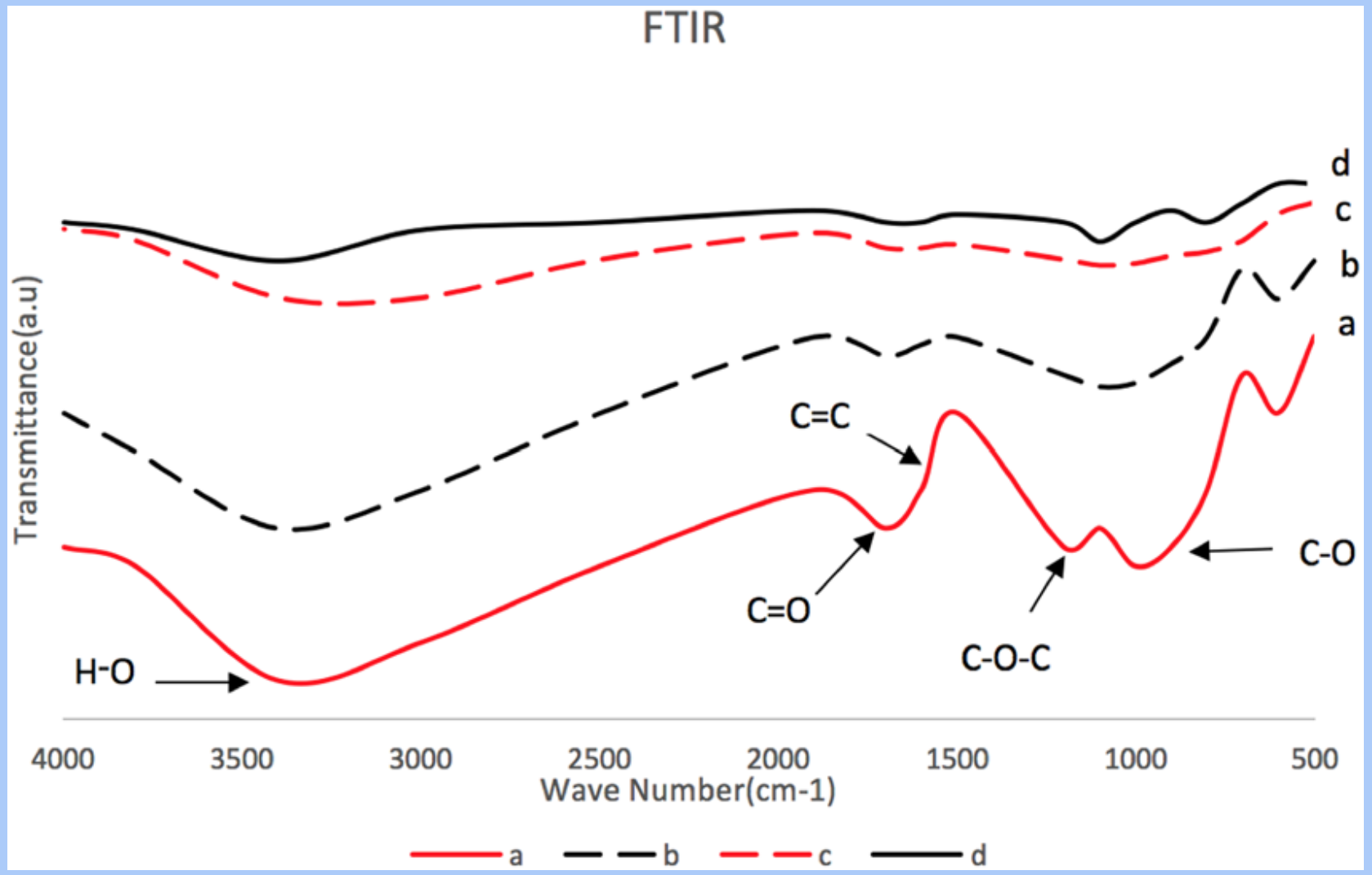
FTIR (Fourier Transform Infrared Spectroscopy)

a) Graphene Oxide
b) r-GO-31
c) r-GO-19
d) r-GO-9



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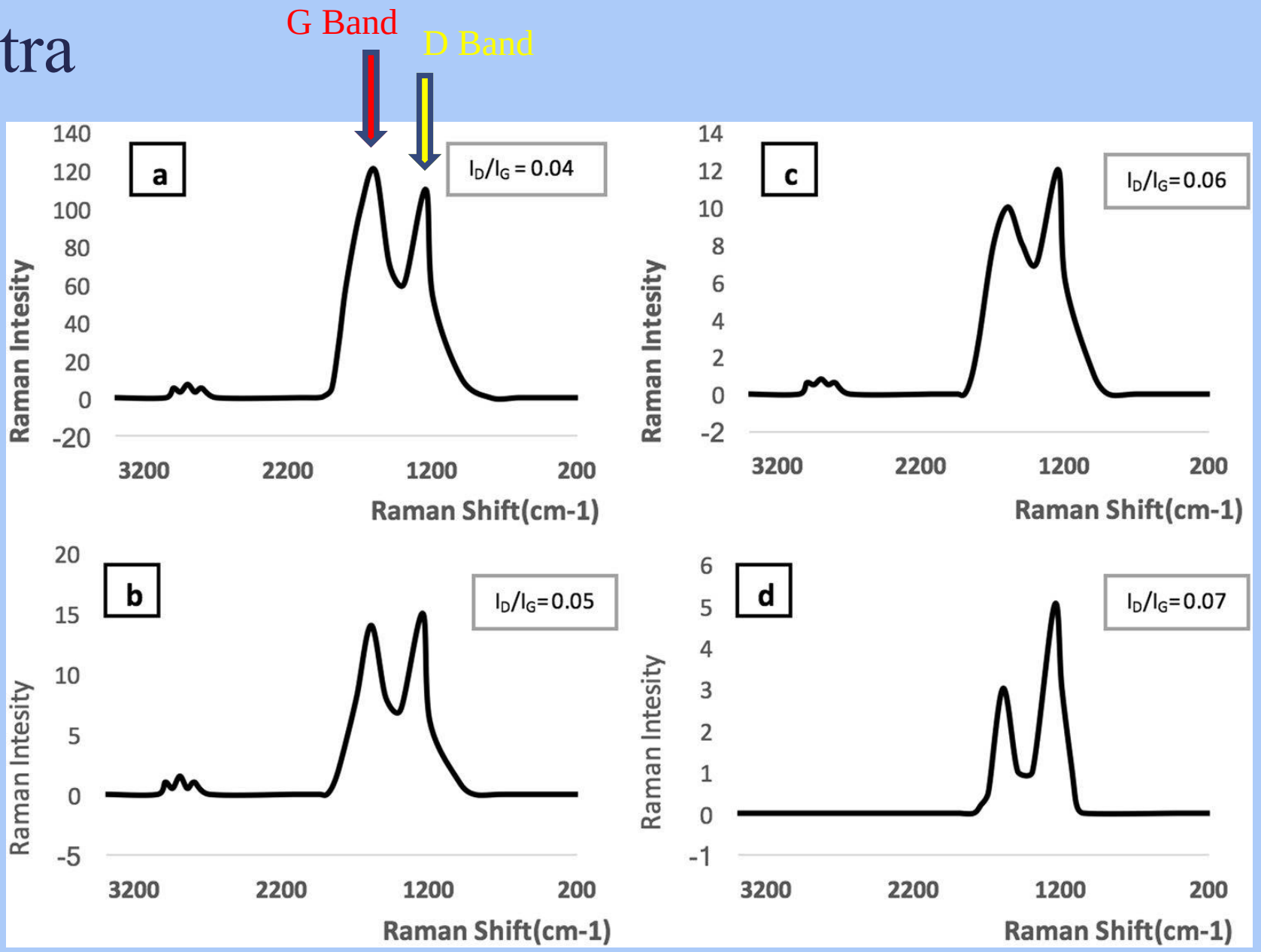
Raman Spectra

a) Graphene Oxide
b) r-GO-31
c) r-GO-19
d) r-GO-9



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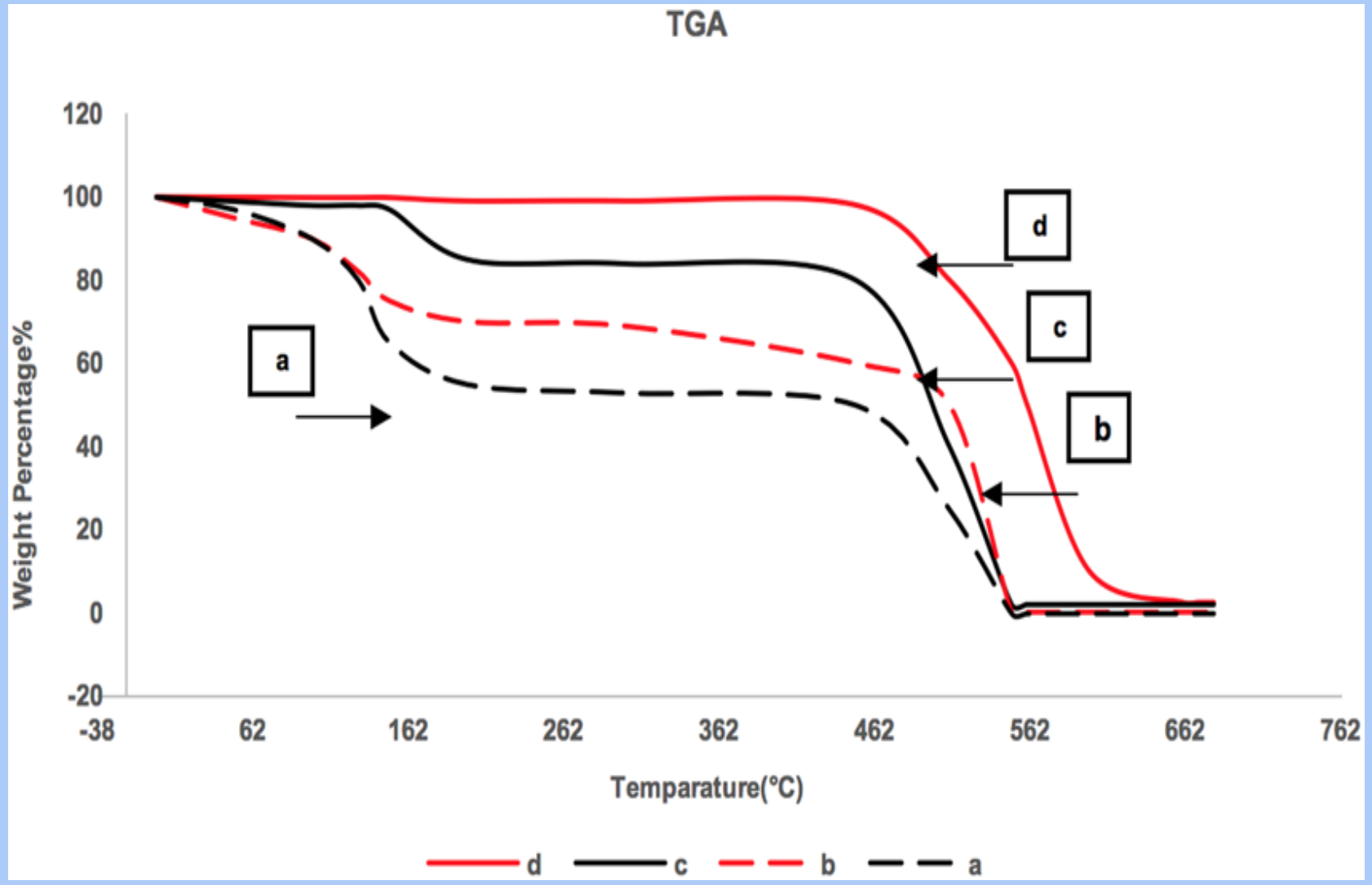
TGA (Thermogravimetric Analysis)

a) Graphene Oxide
b) r-GO-31
c) r-GO-19
d) r-GO-9



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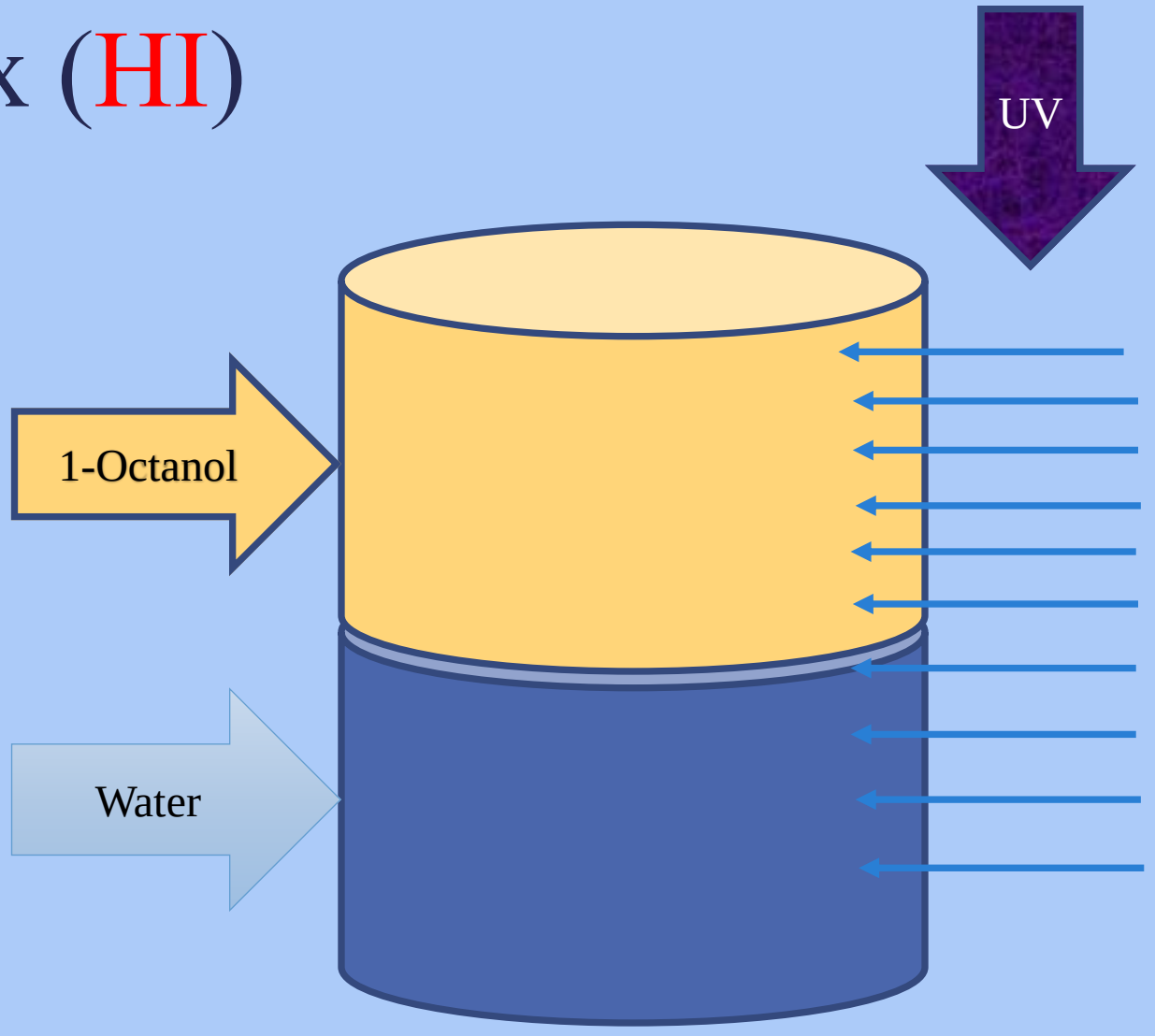
Hydrophobicity Index (HI)

- Dispersibility of GO & rGO in Water
- UV absorbance of GO and r-GOs solutions at 252 nm in water prior to and following 1-octanol extraction.

$$HI(\%) = \frac{(A_o - A_i)}{A_o} * 100$$



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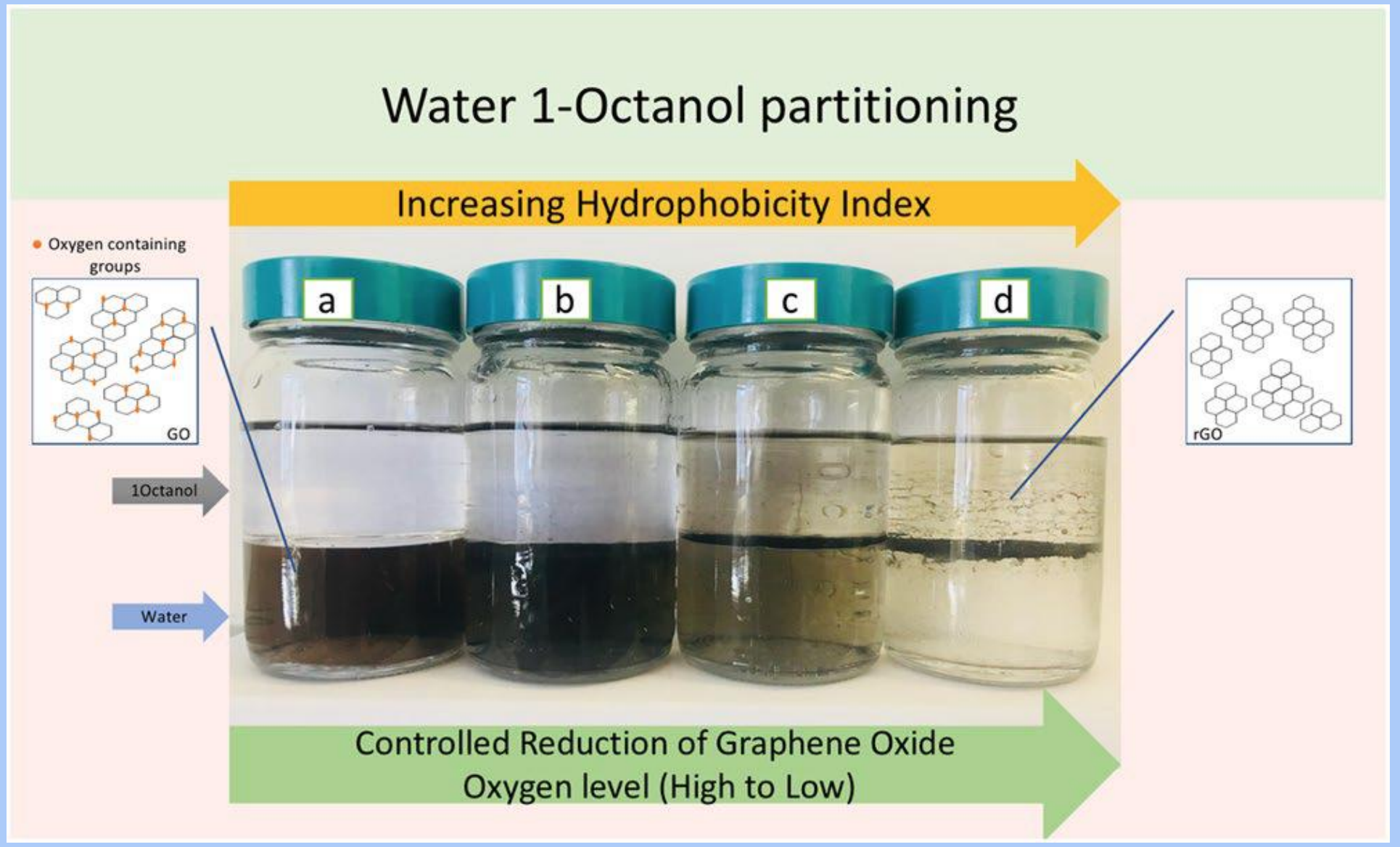

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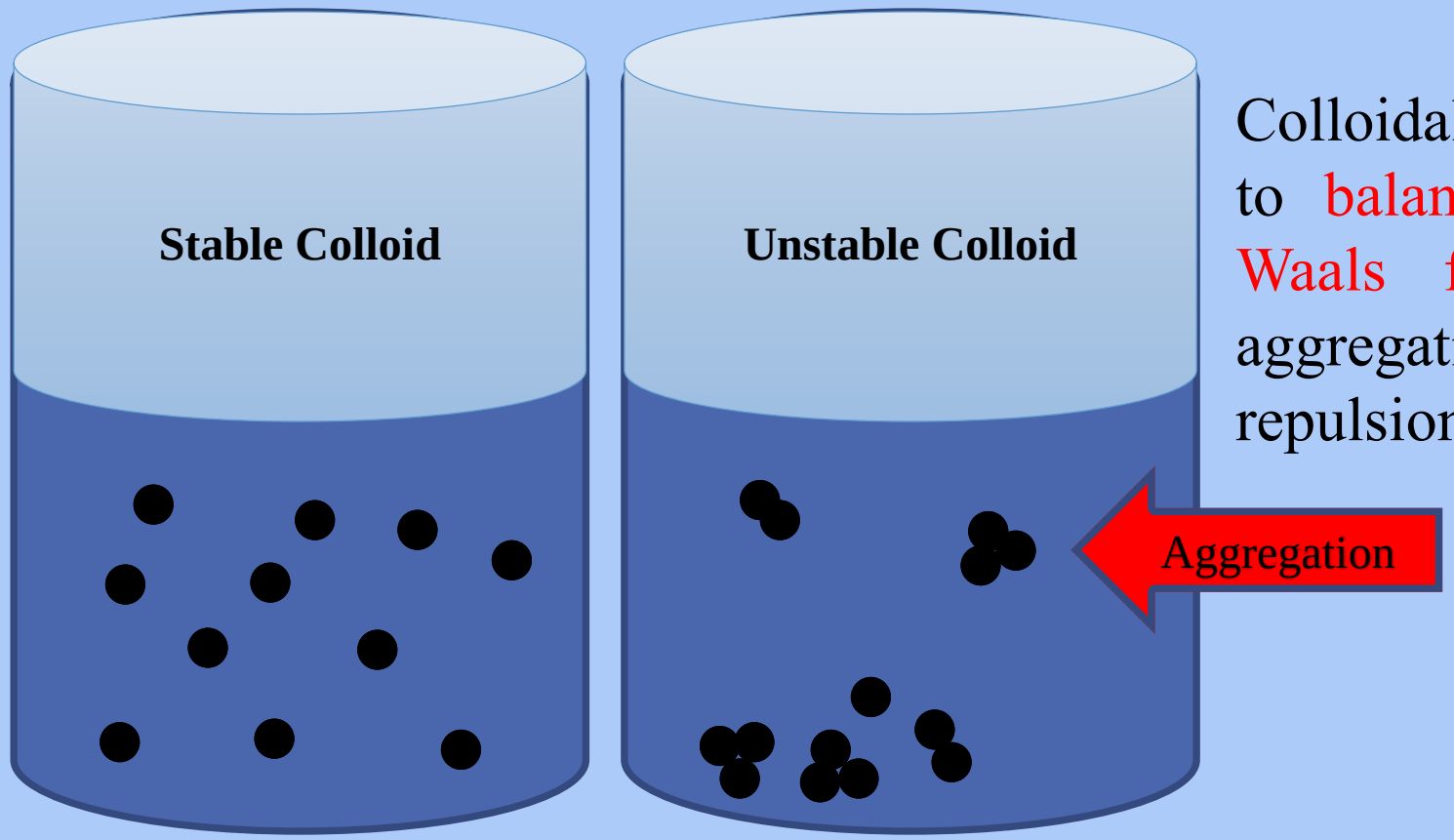
Colloidal Stability

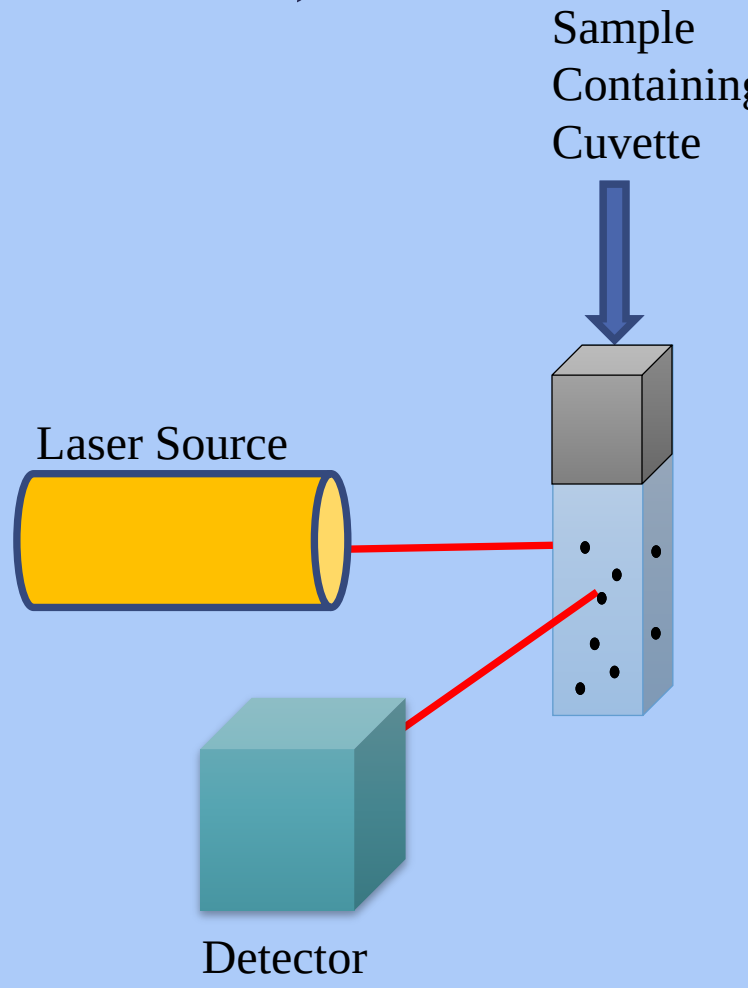


Colloidal stability is attributed to balance between van der Waals forces that promote aggregation and electrostatic repulsion is dispersive.

CCC (Critical Coagulation Concentration)

- The aggregation kinetics of the GO and r-GO were studied using time resolved Dynamic Light Scattering
- Particle size regime is faster at lower concentration of salt and it gets fast as salt concentration increases.
- The attachment efficiency α which is the reciprocal of stability ratio of a dispersion were computed Nacl and Mgcl2.

$$\alpha = \frac{\left(\frac{dr_h}{dt}\right)_{t\to 0}}{\left(\frac{dr_h}{dt}\right)^{(f)}_{t\to 0}}$$



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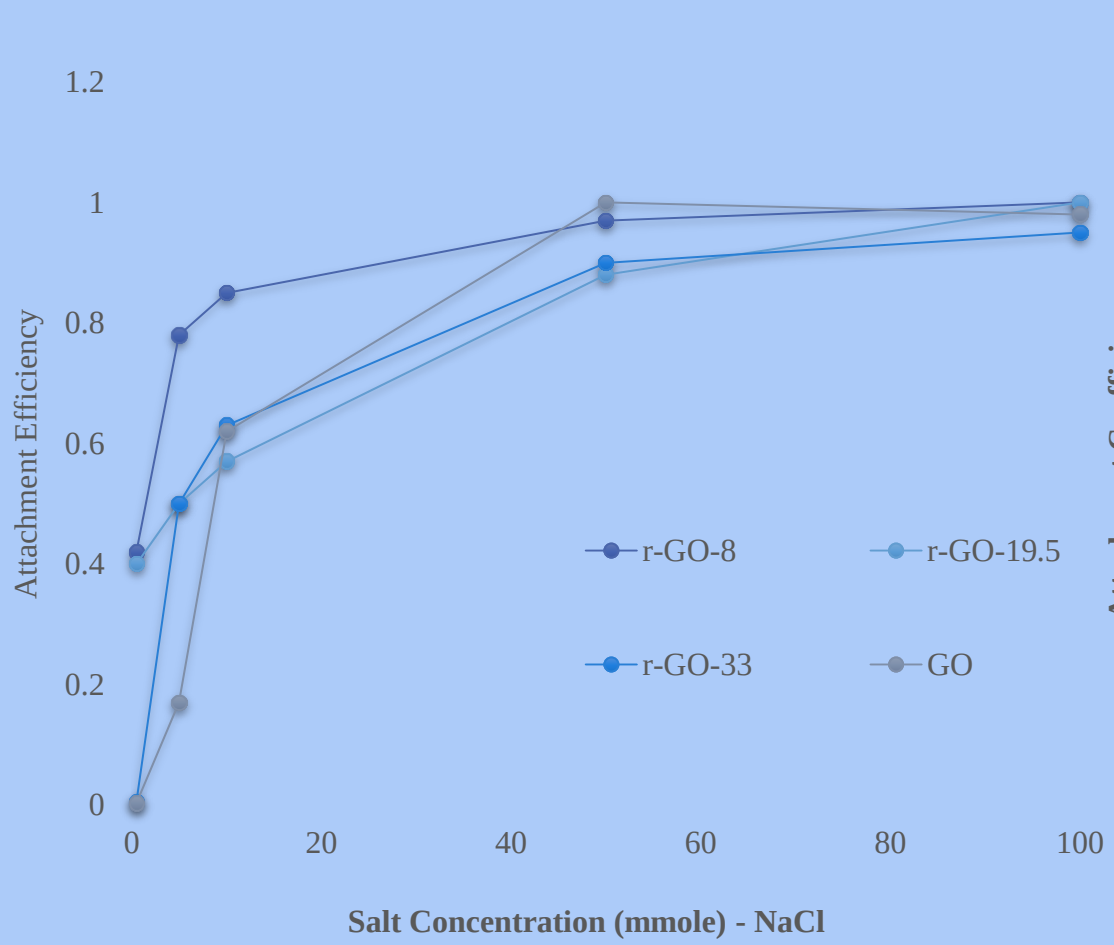
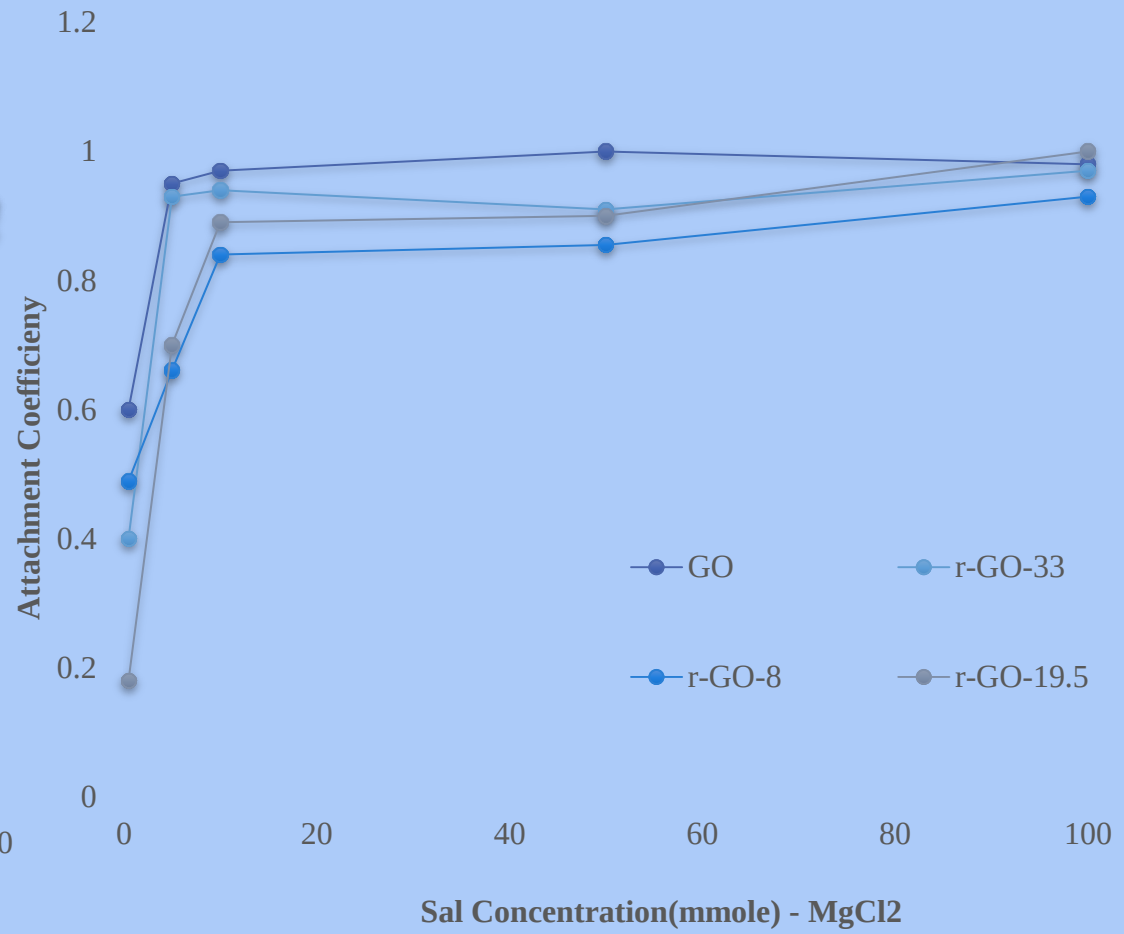
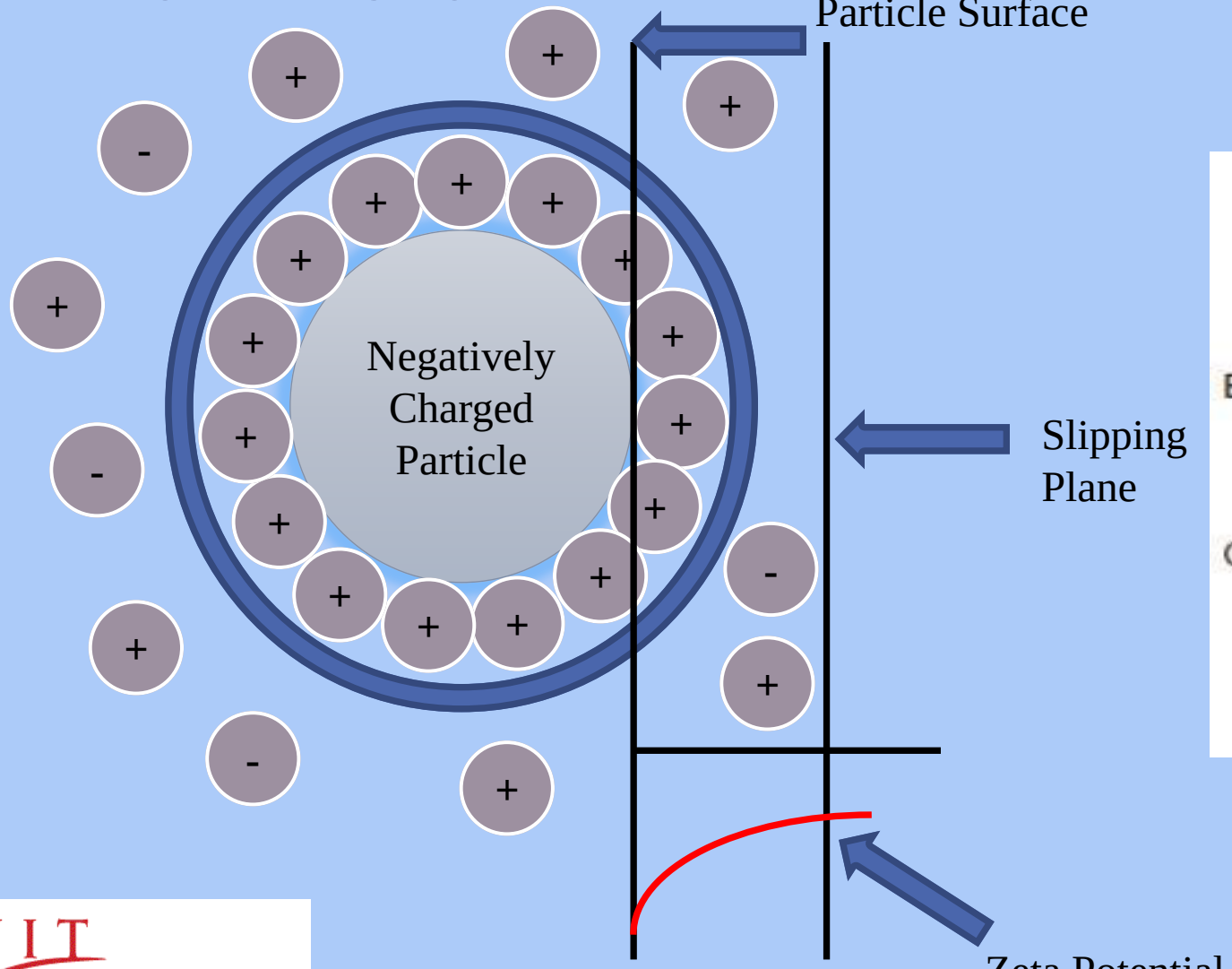
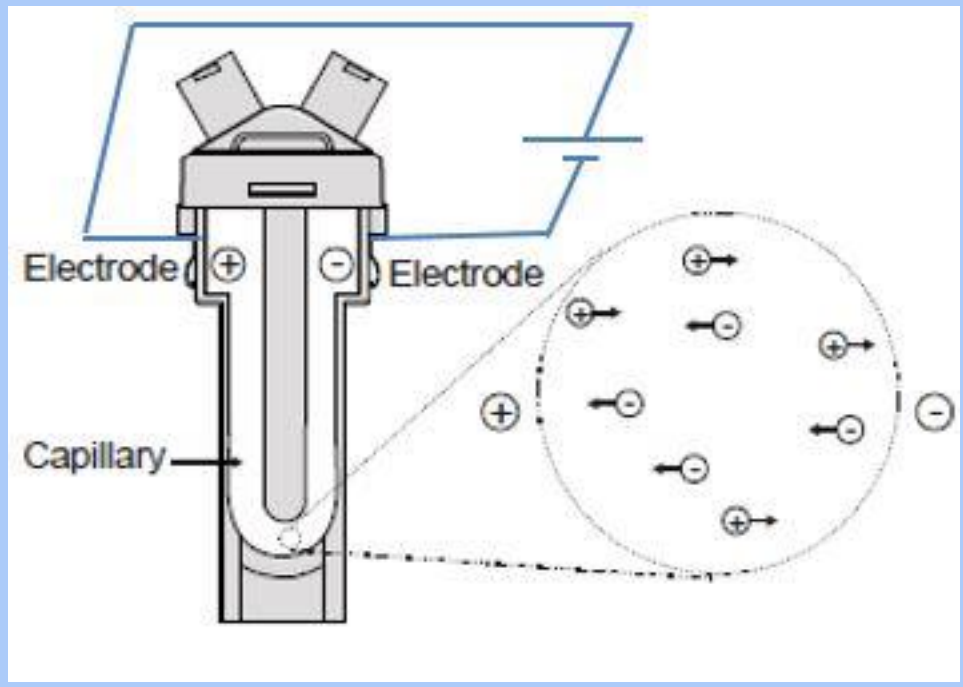
Attachments Efficiency VS. Salt Concentration





Zeta Potential





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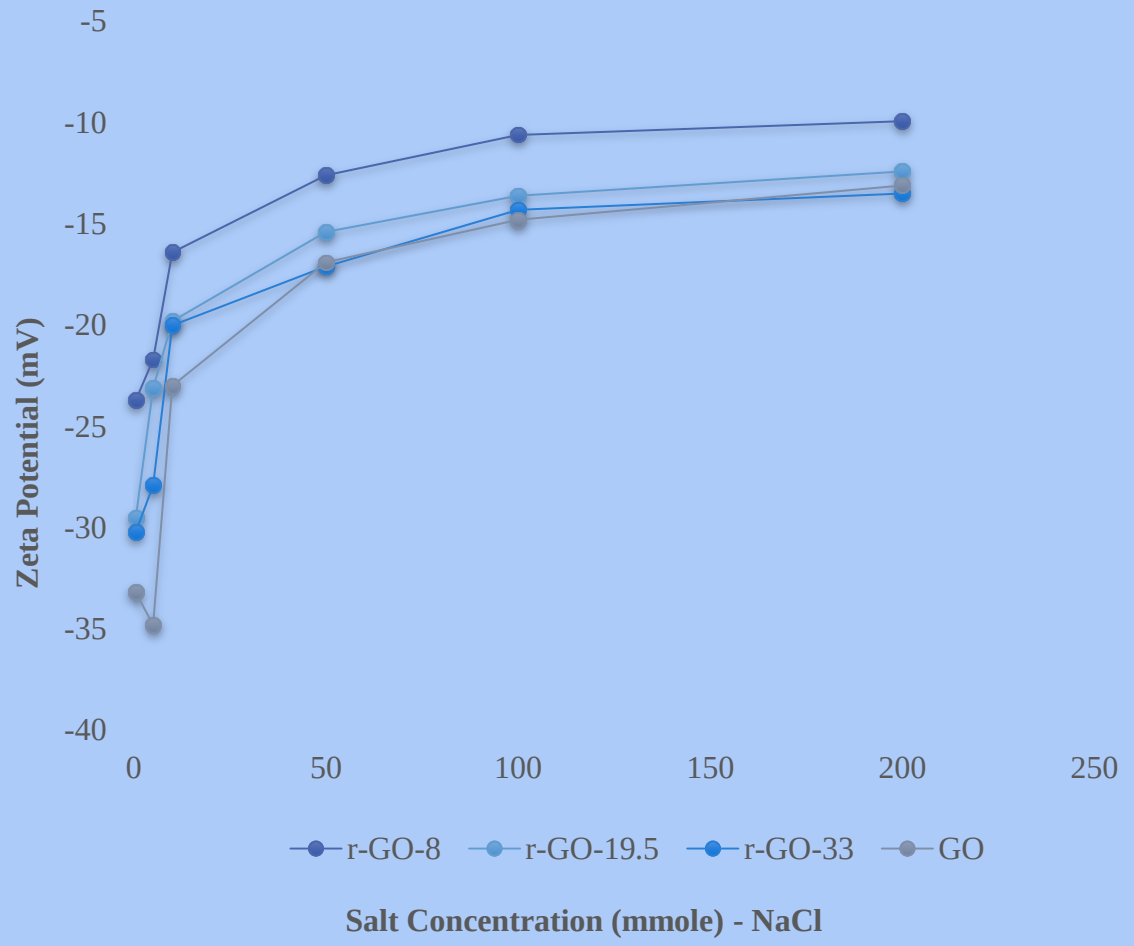
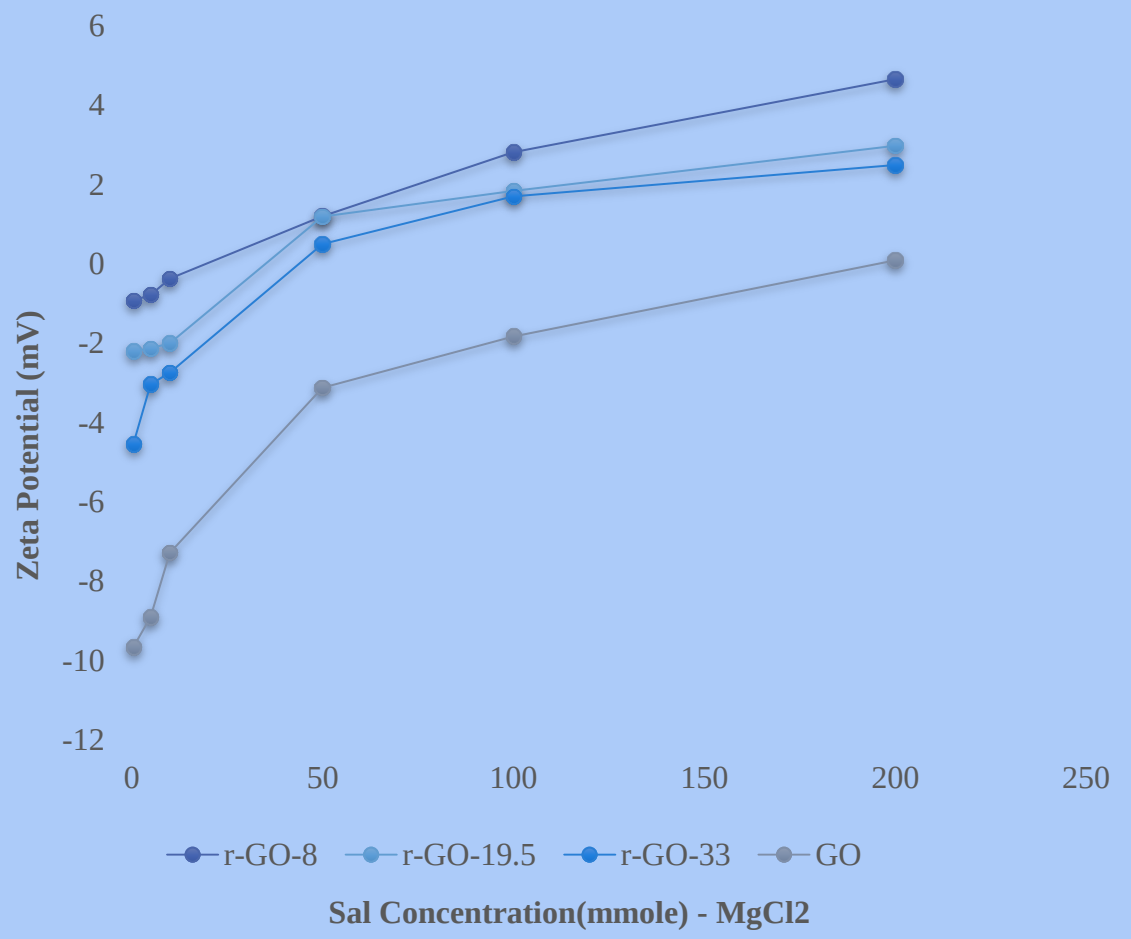
http://www.materials-talks.com/blog/2015/09/24/zeta-deviation-larger-than-the-mean-how-can-that-be/

Zeta Potential VS. Salt Concentration





Summery of findings

Analysis/Sample	GO	r-GO-31	r-GO-19	r-GO-9
Percent Carbon	47.48%	66.87%	80.06%	87.71%
Percent Oxygen	49%	31.67%	19.11%	9.69%
L_a	22.6	18.5	16	13.4
Particle size in 0.5 mmole/1 NaCl(nm)	642.3	385.5	376.7	327.9
CCC in NaCl	28	27	20	15
Particle size in 0.5 mmole/1 $MgCl_2$(nm)	1274	608.2	551.1	358.3
CCC in $MgCl_2$	6	6	5	2
Zeta potential in 0.5 mmole/1 NaCl	−33.2	−30.02	−29.5	−23.7
Zeta potential in 0.5 mmole/1 $MgCl_2$	−9.66	−4.54	−2.2	−0.92
Hydrophobicity Index	−3.89%	0.98%	1.75%	5.2%
Solubility(µg/ml)	7.4	2.1	~0	~0
Dispersibility(µg/ml)	8	6.3	4.1	2.5

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Conclusions

- ✓ Stepwise Reduction of Graphene Oxide carried out by Metal/Acid reaction.
- ✓ Zeta potential, particle size distribution and aggregation kinetics were used to study dispersibility of the different r-GO.
- ✓ The GO and r-GO particles began to aggregate with increase in ionic strength.
- ✓ Surface oxidation in r-Go clearly played an important role and higher oxygen content led to higher CCC values.
- ✓ Solubility of graphene oxide in water decreases by decreasing oxygen containing groups.

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Thank you for Listening

Questions and Comments

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