

# Processable aqueous dispersions of graphene nanosheets

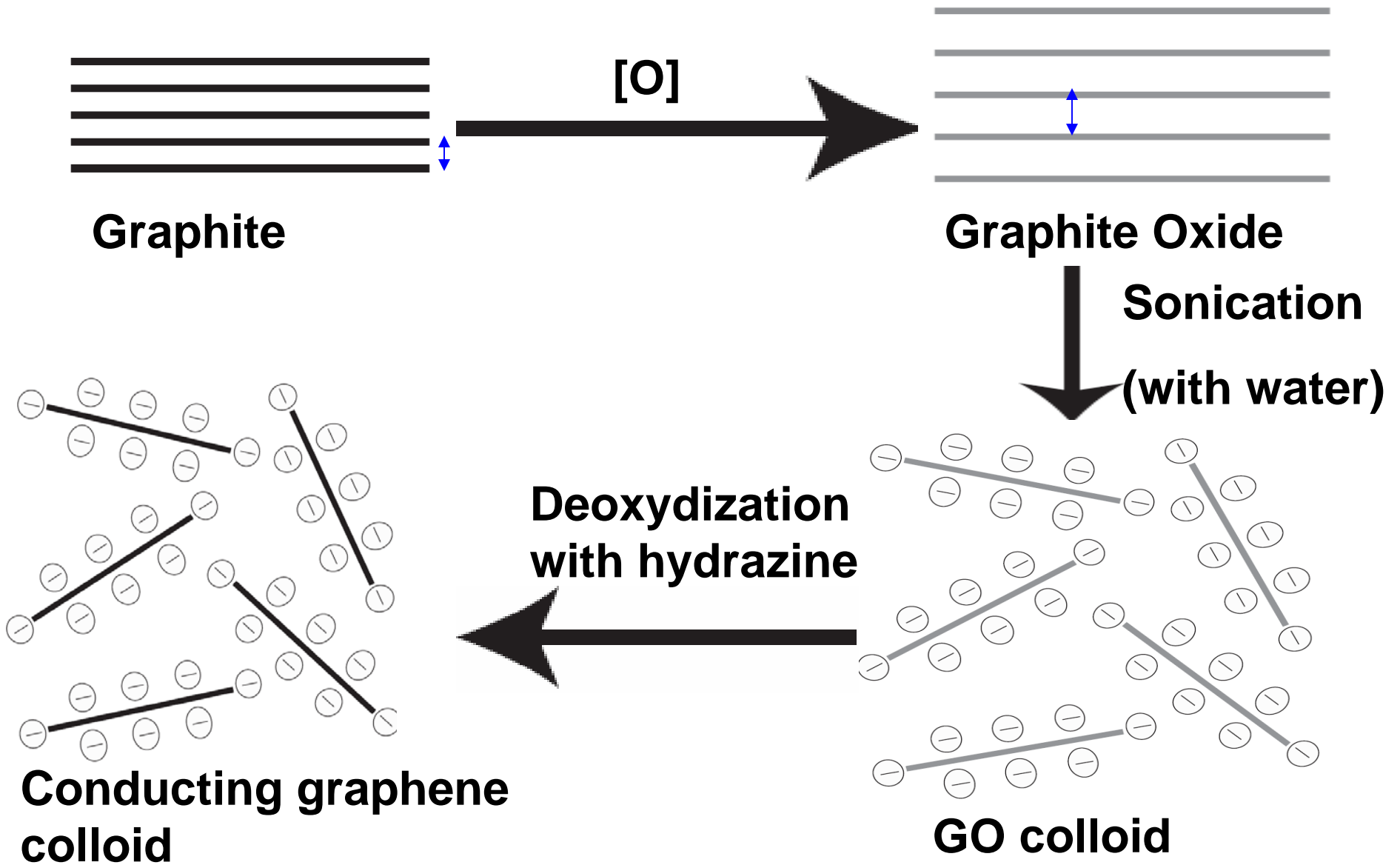
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*The problem was...*

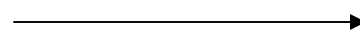
*Lack of **efficient** approach to  
produce **processable** graphene  
sheets **in large quantities***



**Scheme showing the chemical route to the synthesis of aqueous graphene dispersions**

# THE LOGIC

Information in hand



Exfoliated GO forms well dispersed colloid



Reason ?



Only a presumption: hydrophilicity

Surface Study!



Result: GO sheets are negatively charged in water



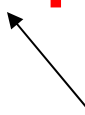
Why? What are the extra components?



IR study: phenolic -OH, carboxylic acid groups

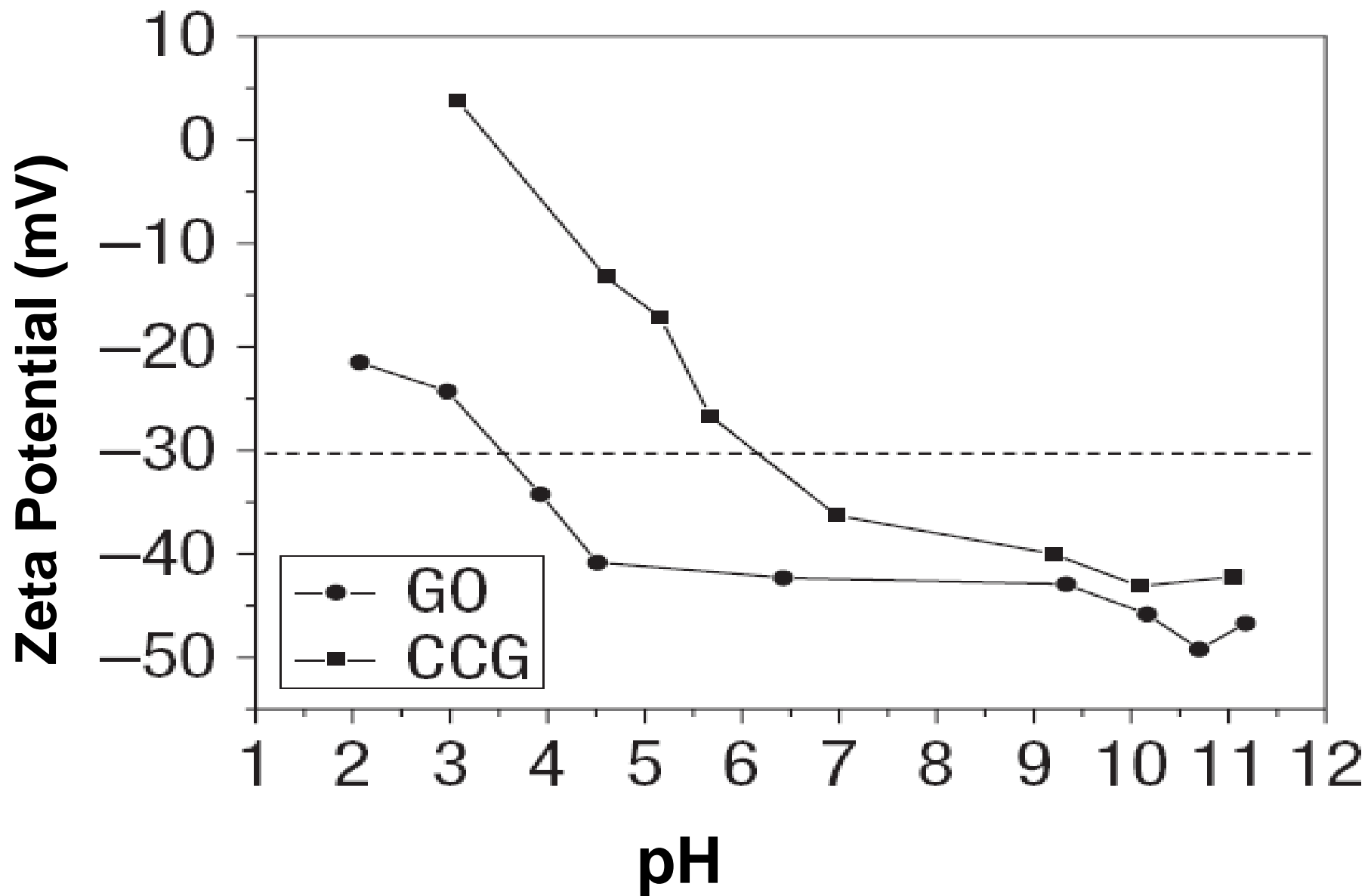


Electrostatic repulsion

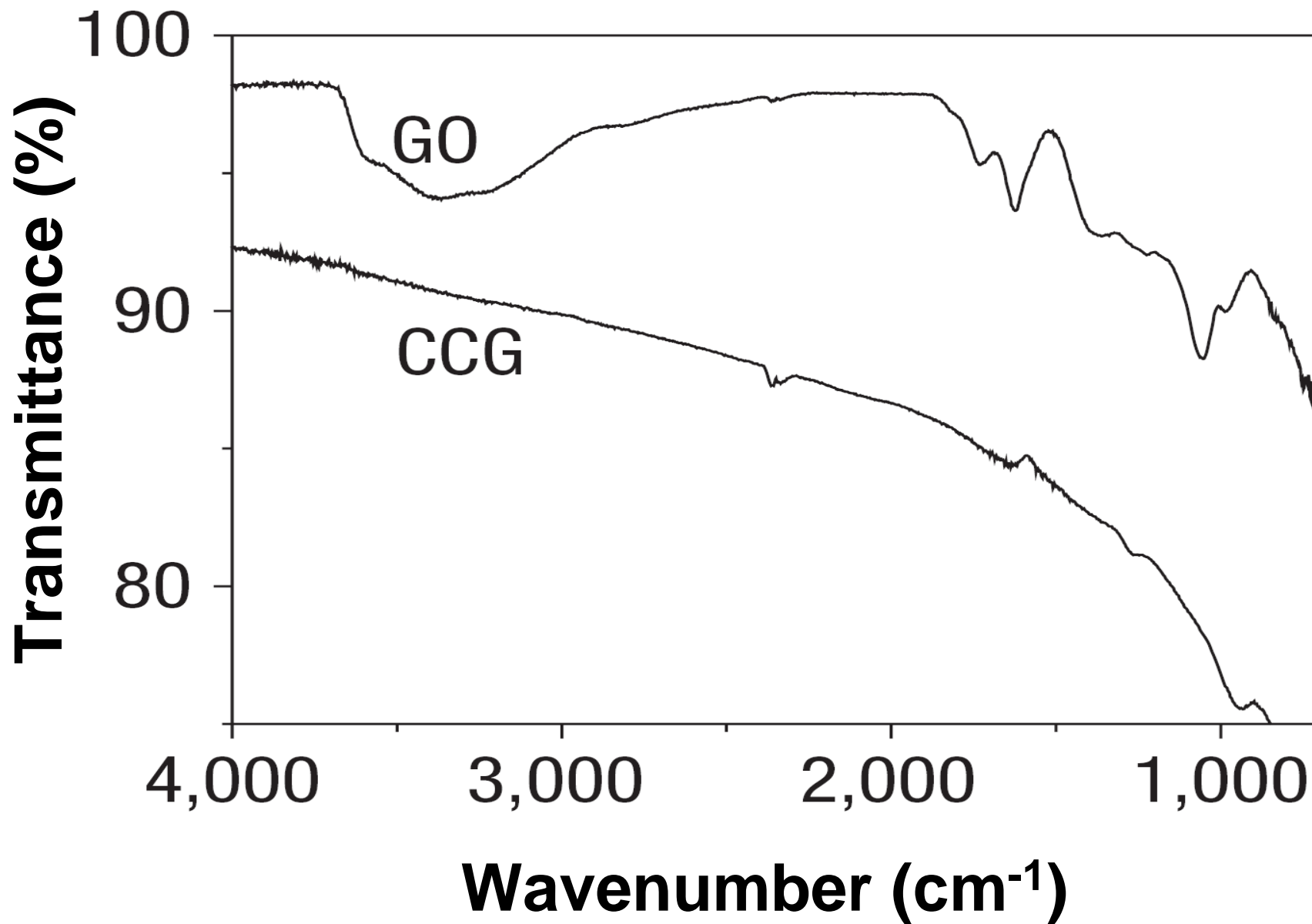


Need is electrostatic repulsion in the reduced product!

**Surface properties  
of  
GO and CCG.**



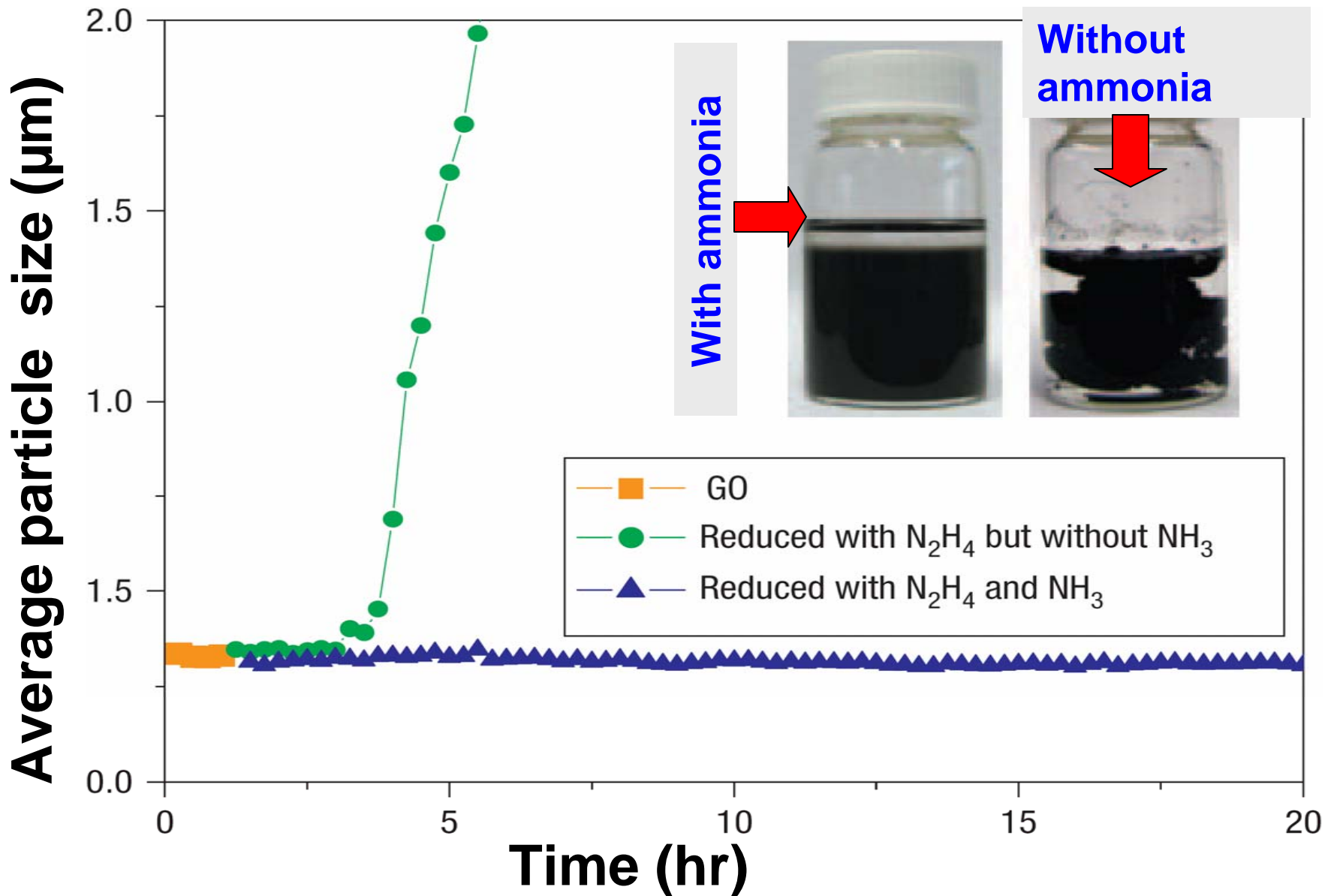
**Zeta Potential of GO and CCG  
as a function of pH**



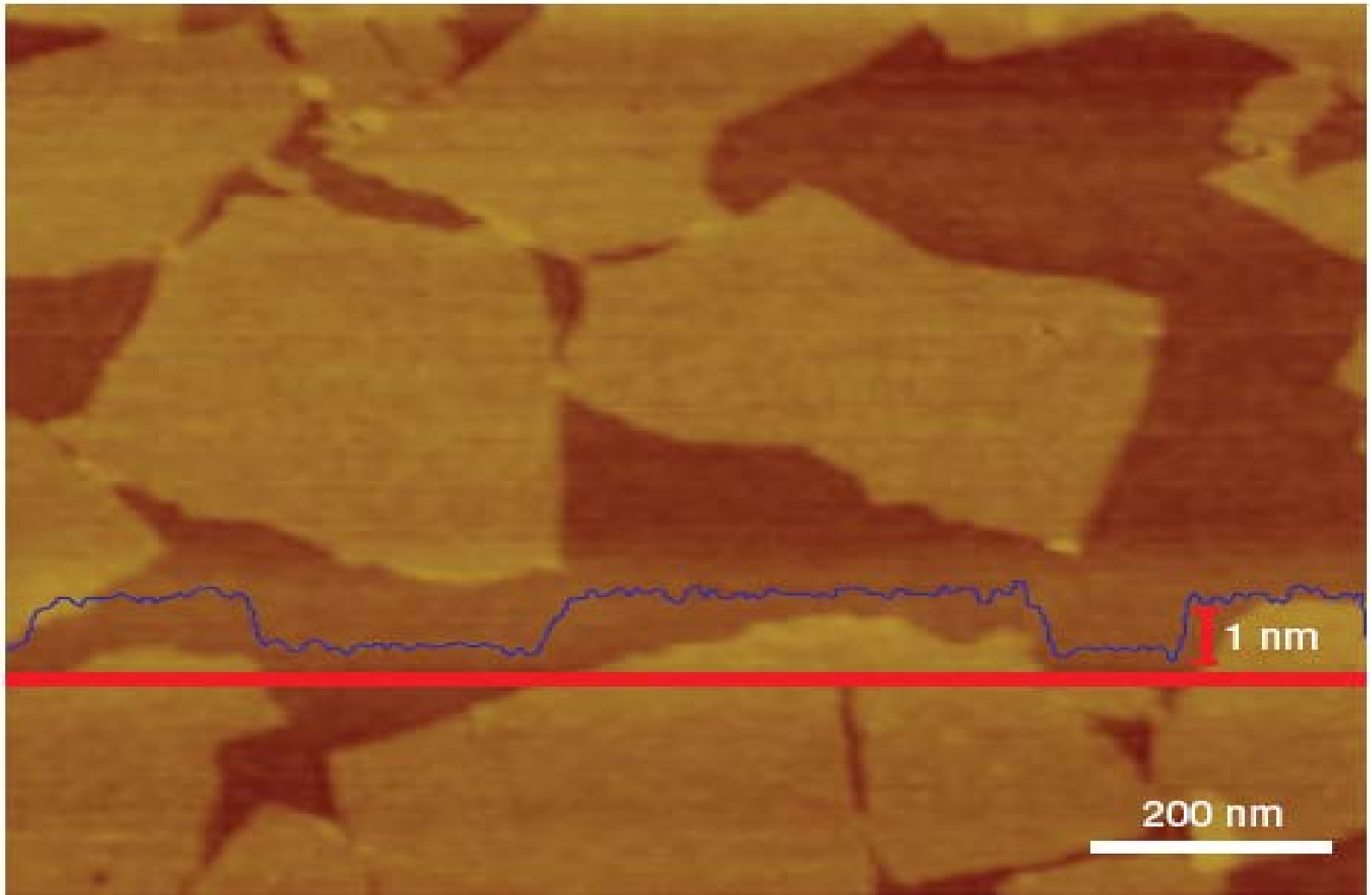
**FT-IR spectra of GO and CCG**

**Colloidal and morphological  
characterization of  
CCG dispersions**





**Effect of addition of ammonia on the dispersion state of CCG sheets**



**Tapping mode AFM image of CCG sheets with a height profile (blue curve; scale bar, 1 nm) taken along the red line.**

**No increase in particle size of CCG after completion of reduction**



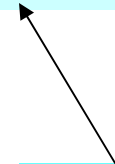
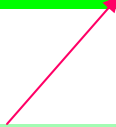
**CCG sheets are separated in the dispersion**

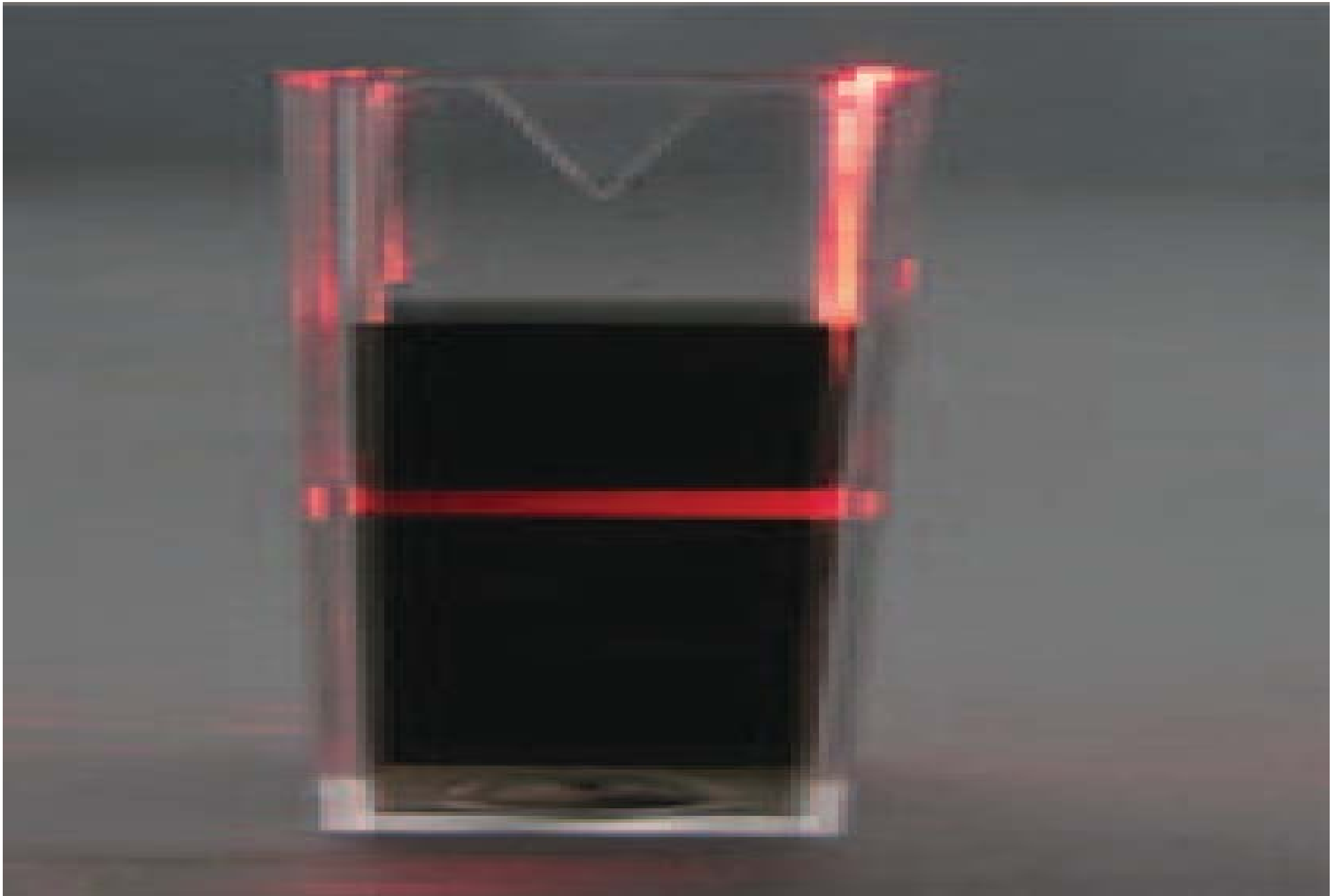
**No sediment**

**Thickness of resulting sheets = 1nm**

**Centrifugation of dispersion at 4000 rpm**

**AFM**





**The Tyndall effect**

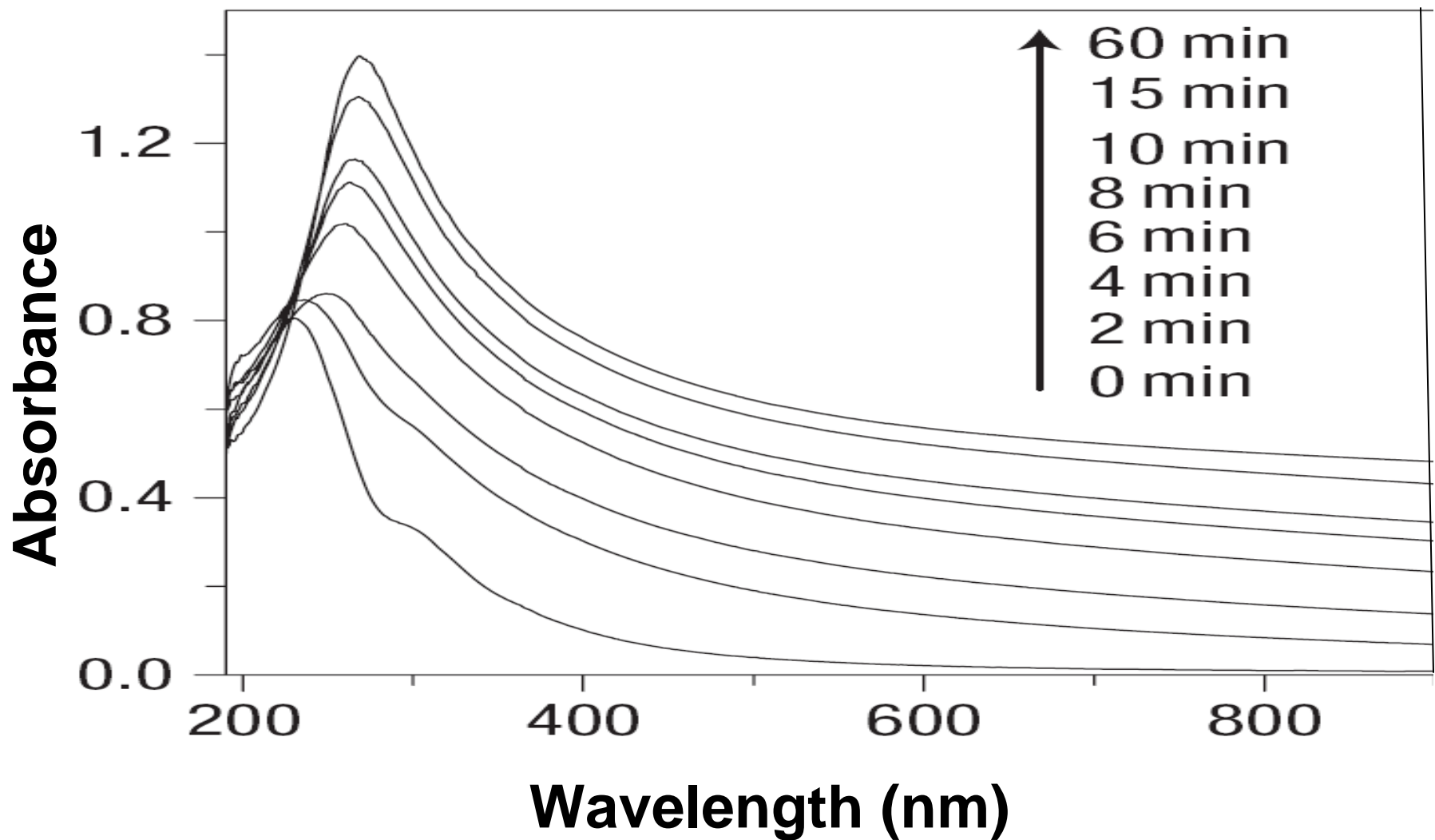


**NaCl**



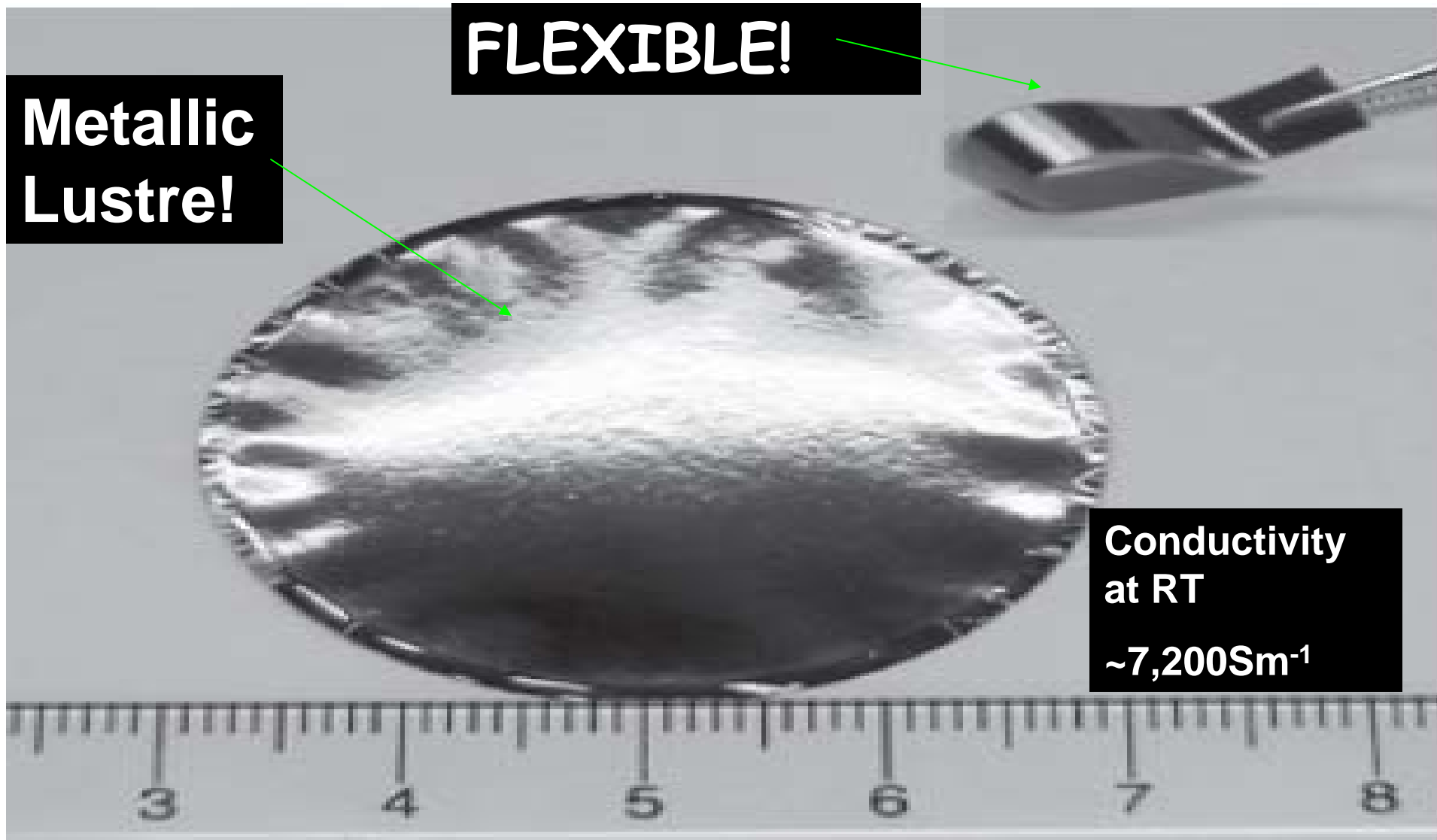
## **The salt effect**

**highlights the importance of complete removal of residual salts and acids from the starting GO solution**



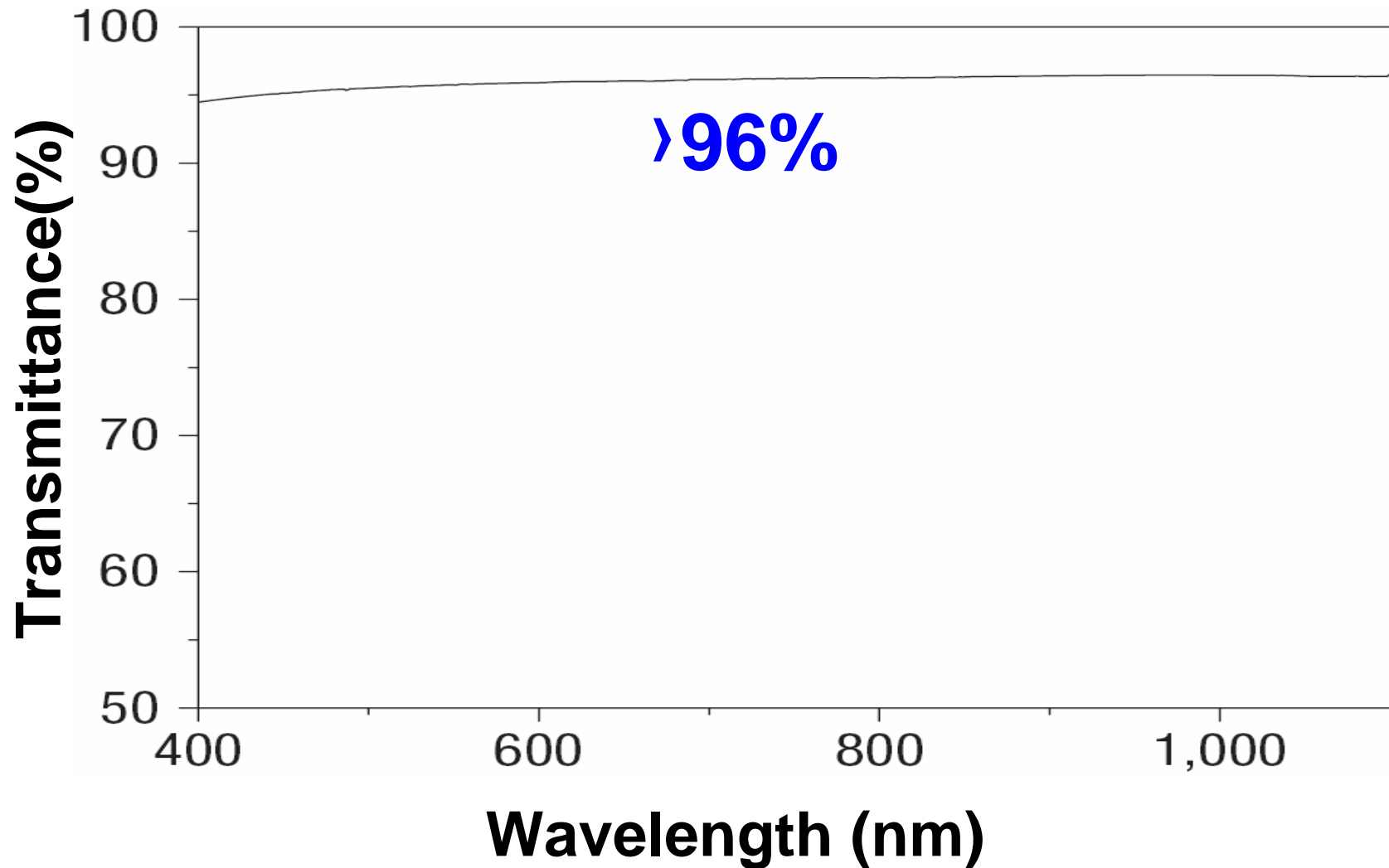
**UV-vis absorption spectra  
showing  
the change of GO dispersions as a function of reaction time**

**Examples demonstrating that films made of CCG sheets can be easily fabricated from CCG dispersions using various solution-phase processing techniques**

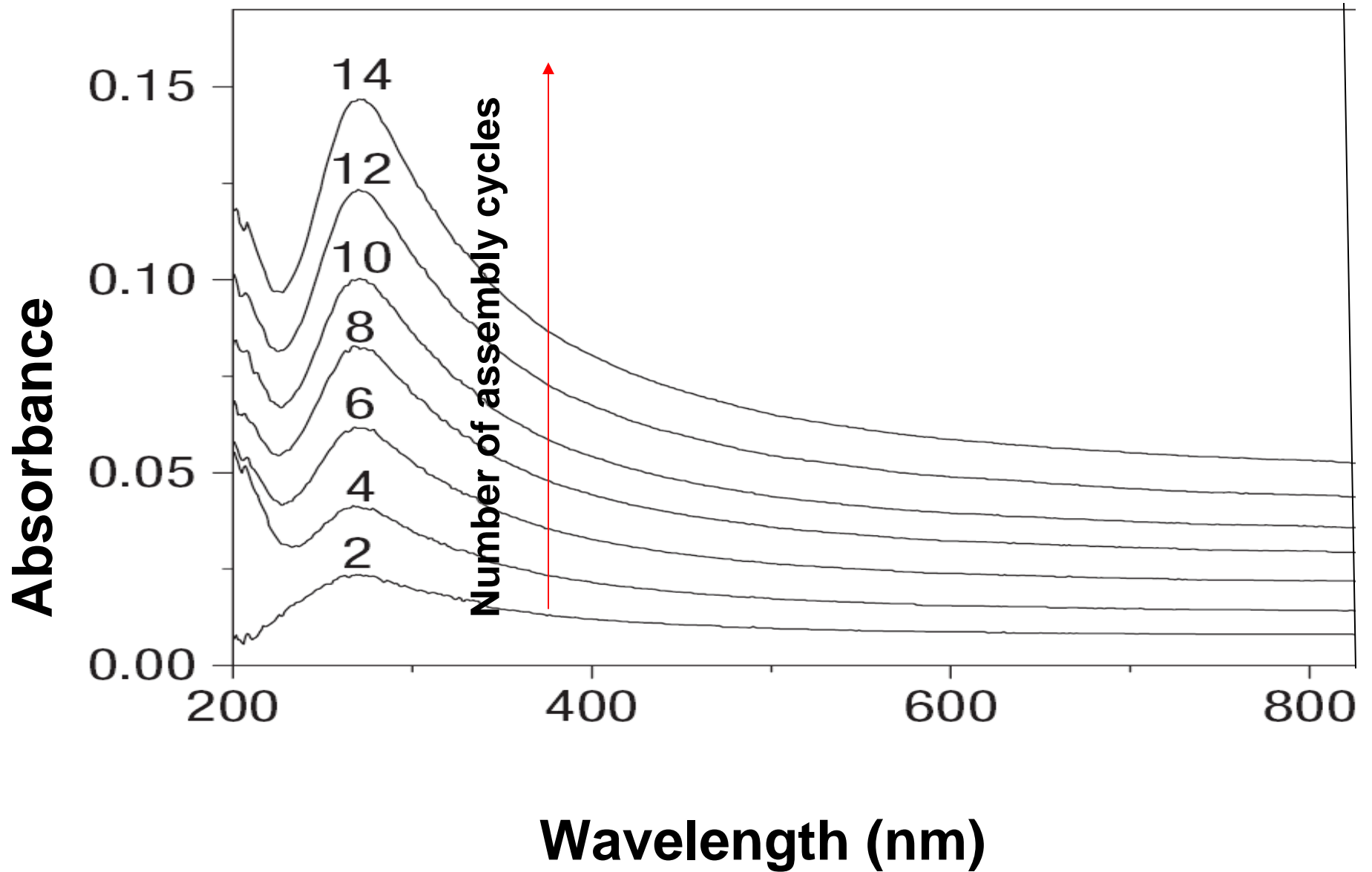


**A 10-mm-thick CCG film or paper prepared by vacuum filtration of a CCG dispersion through an alumina membrane**





**A transmission spectrum of a CCG coating deposited on a glass slide by air-brush spraying of a CCG solution**



**UV-vis spectra of polycation/CCG films**  
prepared by a layer-by-layer electrostatic self-assembly technique

# Importance of the process

- *provide a **low cost solution** processing technique for graphene.*
- *opens up enormous **opportunities to use graphene** for many technological applications*

*I believe as a scientist I should not exaggerate the potential of my field. We should be modest and not become political about the technology and research at hand. This is one of the reasons I do not give many talks about nanotechnology.*

**-Sumio Iijima**

