Removal of Metal Contaminants from Aqueous Solution by New Filtration Methods

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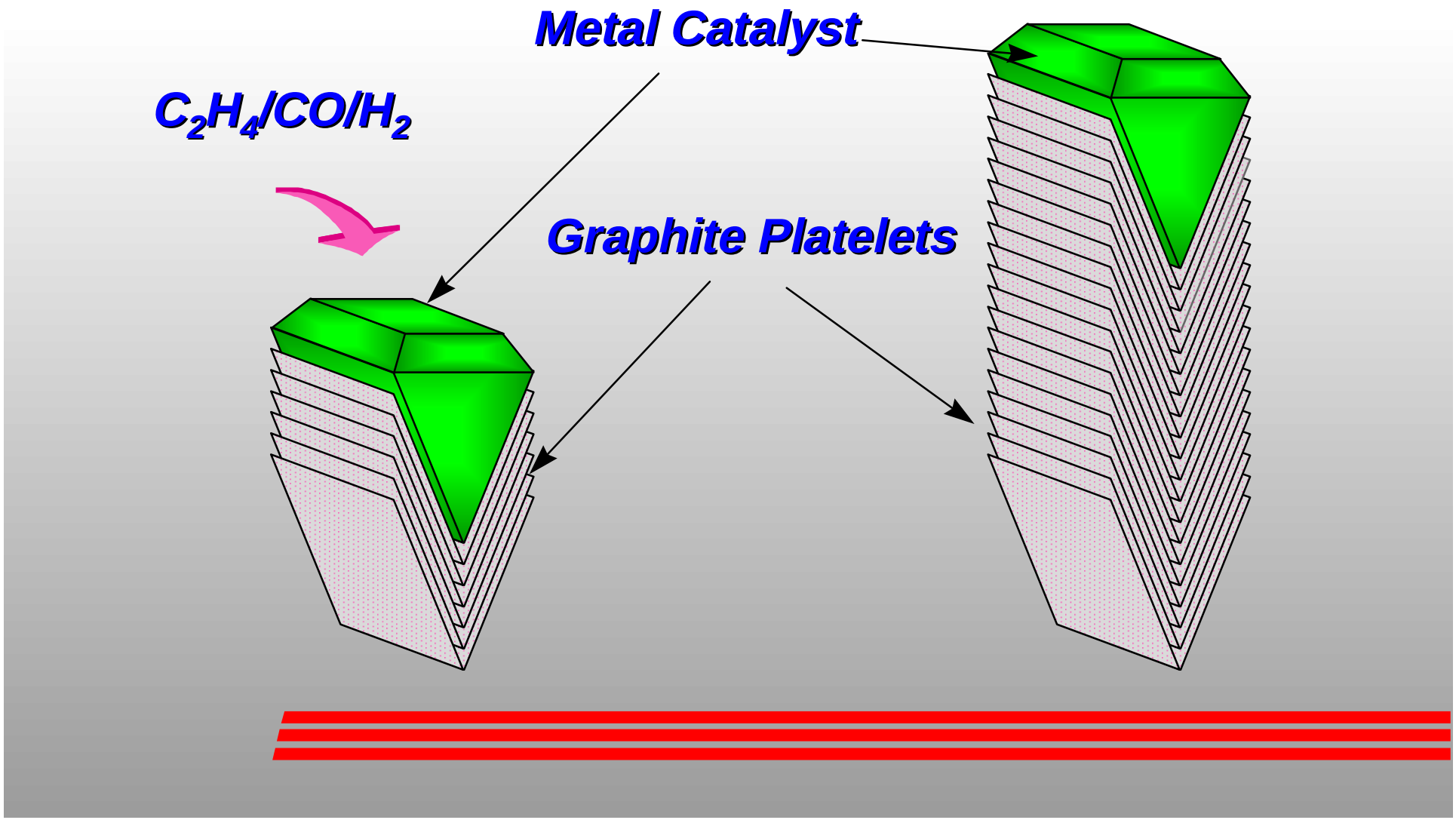
Objective of Research Program

- Graphite Nanofibers (GNF) are a rare type of material where high surface area and high conductivity are simultaneously found.
- These materials constitute one of the finest molecular sieves and as such selective adsorption can be achieved.
- We intend to take advantage of the unique properties of these materials to:
  - *Electrochemically remove metal contaminants from aqueous streams*
  - *Capture organic molecules between the graphene layers*

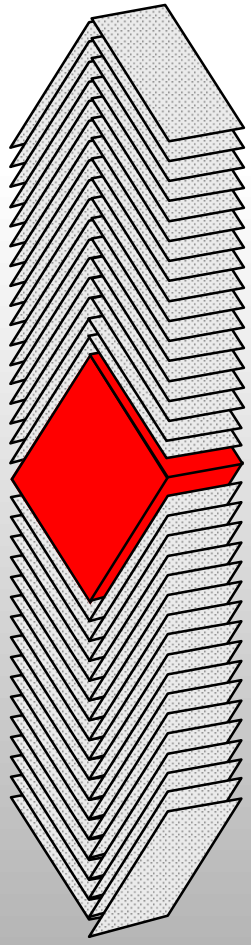
Graphite Nanofibers (GNF): a Catalytically Engineered Material



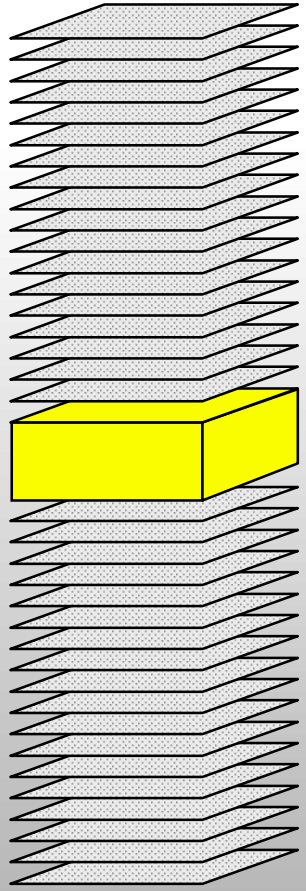
Growth Mechanism of GNF

- GNF are produced by the decomposition of carbon containing gases over selected metal catalyst particles.
- Following adsorption over certain faces of the metal particle, dissociation of C-C bonds occurs.
- Carbon species diffuse through the body of the particle to precipitation through another set of metal faces and form graphene layers .
- Unlike any other carbon material, GNF consists only of graphite edges, which bestows the material with unique adsorption properties.

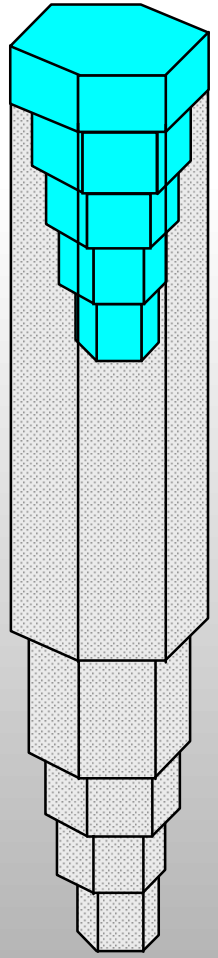
GNF Structures



(a) Herring-bone



(b) Platelet

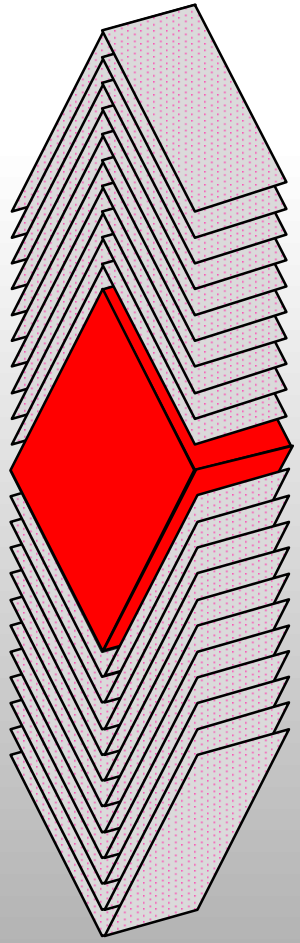


(c) Tubular

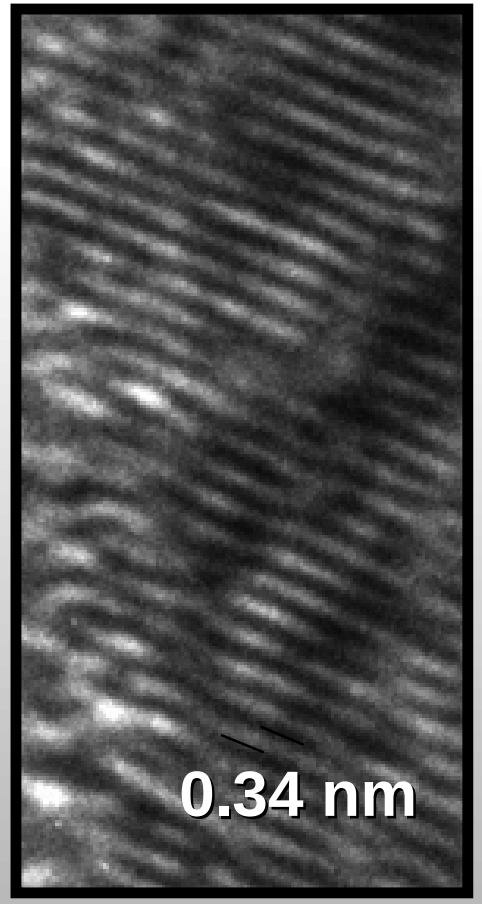
GNF Structures

- There are several types of GNF structures, which are dependent on the nature of the catalyst, the temperature and the reactant gas.
- Three main types of conformations ***Herring-bone:*** *where the graphene layers are located at an angle with respect to the fiber axis (model a).*
  - ***Platelet*** *where the graphitic layers are oriented* ***Tubular:*** *where the layers are oriented parallel to the fiber axis (model c)*

Herring-bone GNF

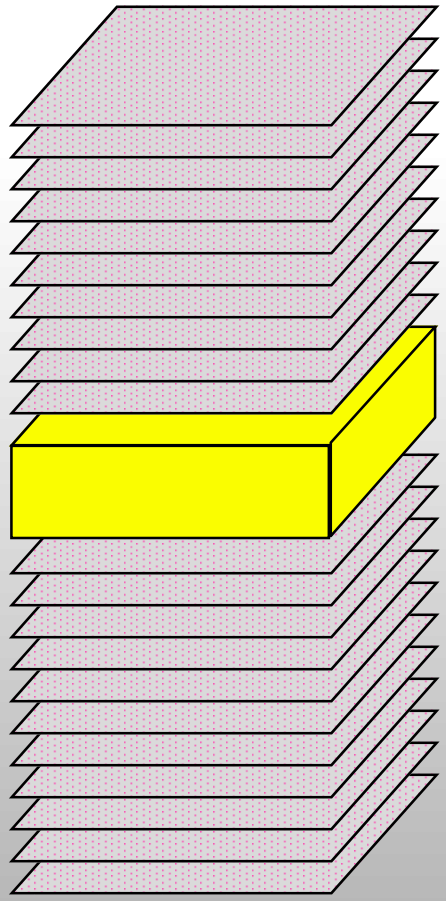


Schematic Diagram of GNF

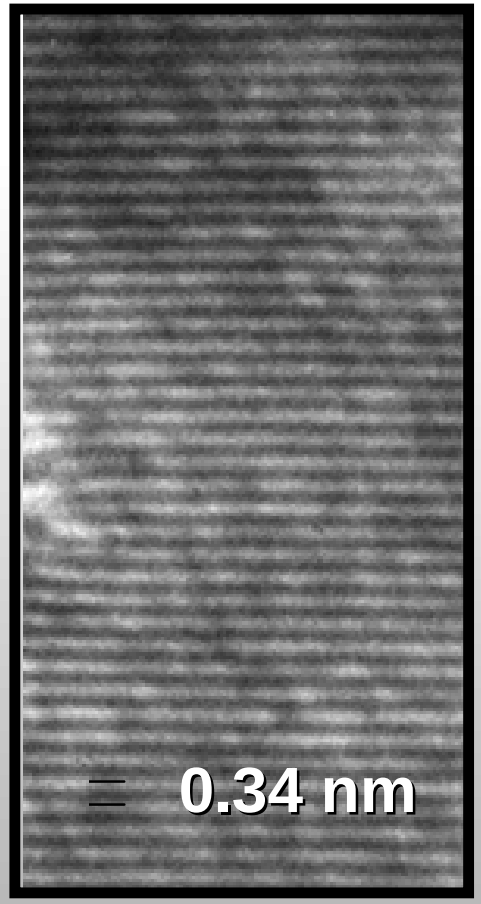


HRTEM of GNF

Platelet GNF

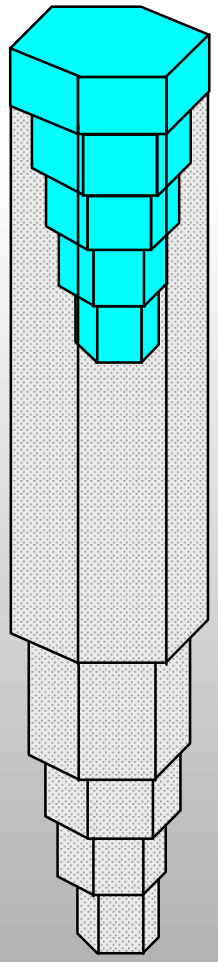


Schematic Diagram of GNF

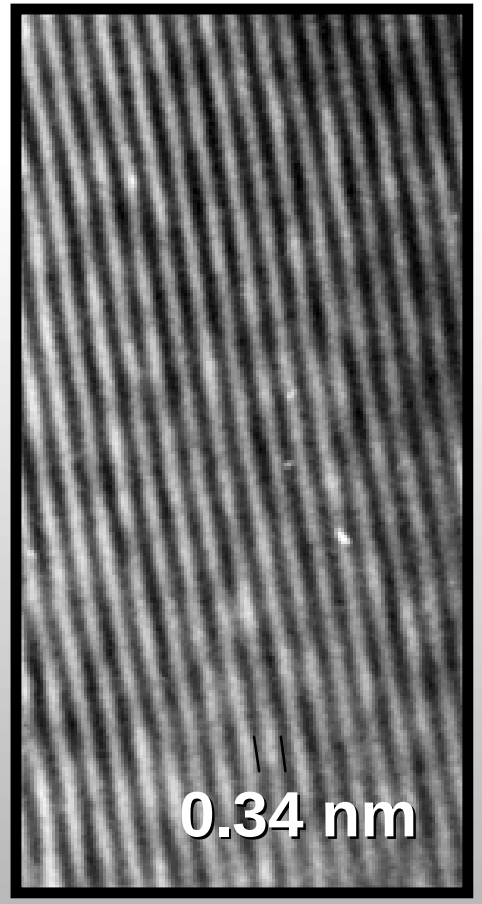


HRTEM of GNF

Tubular GNF

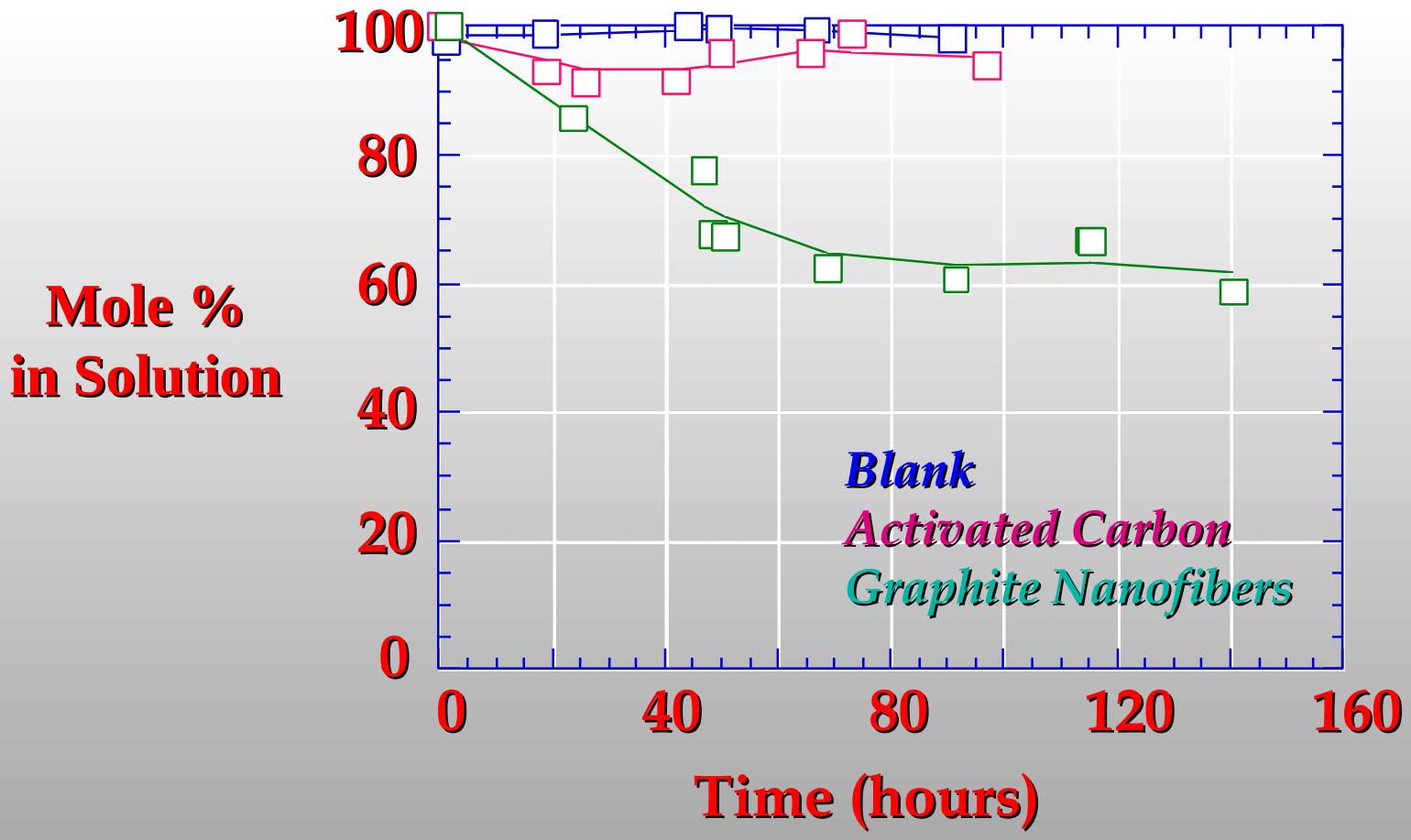


Schematic Diagram of GNF

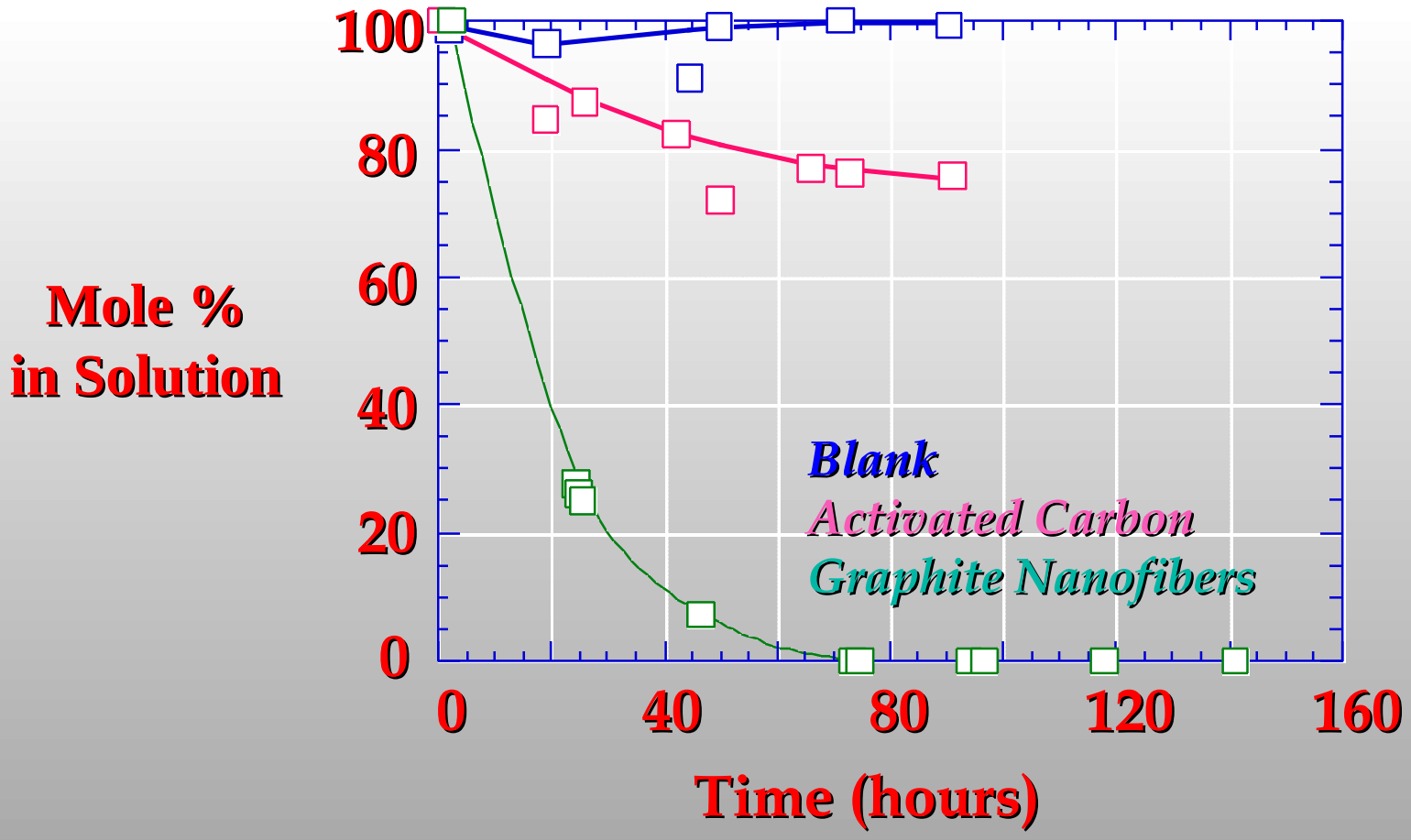


HRTEM of GNF

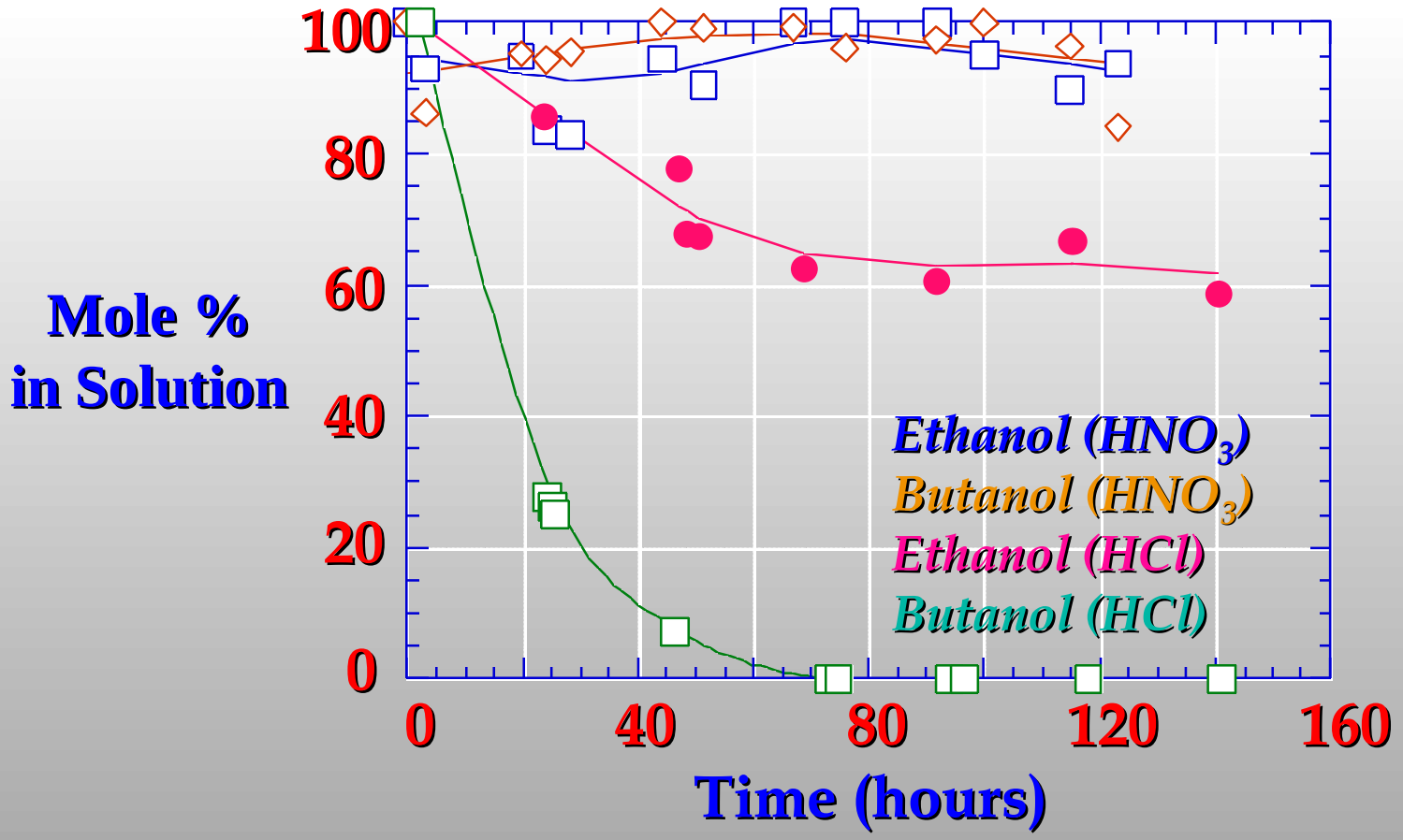
Adsorption of Ethanol on Carbons



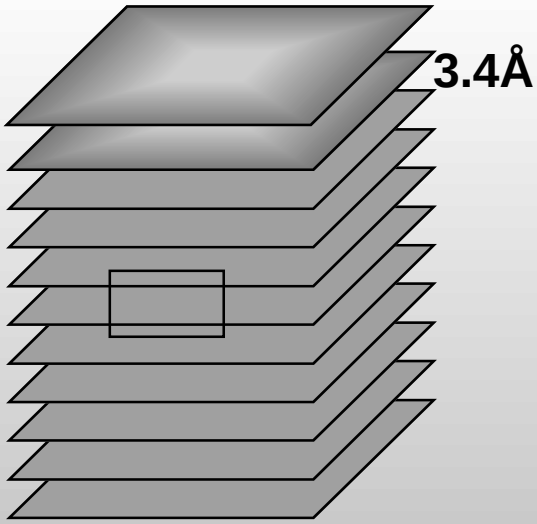
Adsorption of Butanol on Carbons



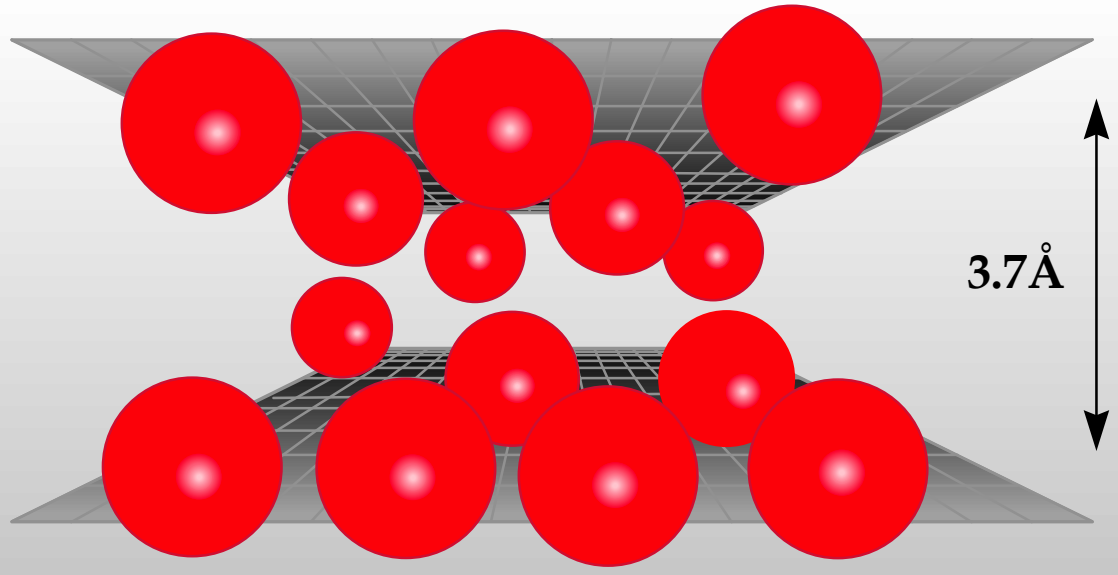
Effect of Acid Treatment on the Adsorption of Alcohols in GNF



Adsorption of Organic Molecules



GNF



Enlarged section of GNF

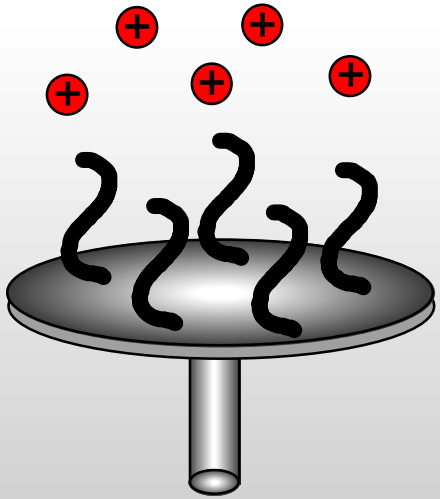
- Organic molecules possessing low polarity are selectively adsorbed between the graphite layers

Summary

- GNF have the ability to selectively remove organics from an aqueous solution and in contrast to active carbon do not become saturated with the solvent.
- In this context, GNF exhibit a higher affinity for the less polar molecules.
- X-ray diffraction analysis shows that when HCl treated GNF are allowed to interact with butanol the organic intercalates between the graphene sheets and causes a significant expansion in the interlayer spacing of the adsorbent.
- This phenomenon was not observed when the same type of GNF were treated in either HNO_3 or H_2SO_4.

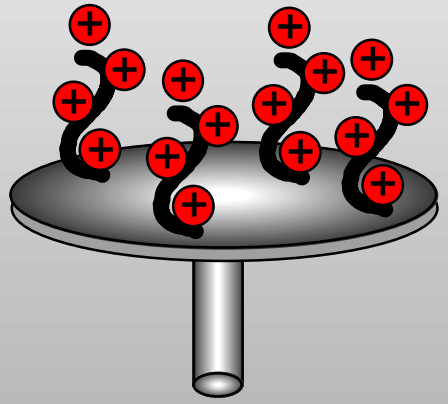
Metal Removal

Metal Ions



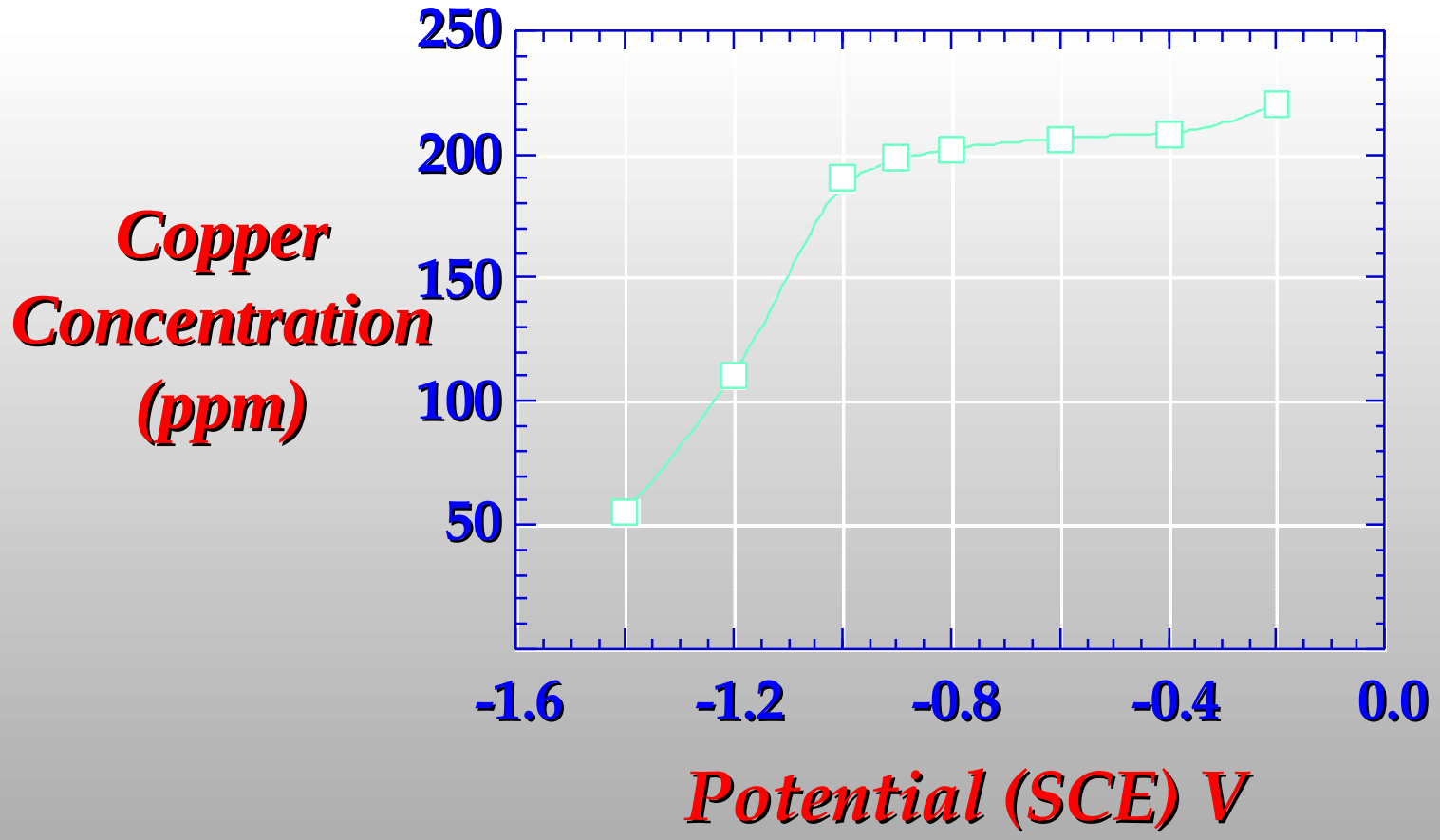
Graphite Nanofiber Electrode

(a) Electrochemical Deposition



(b) Electrosorption

Cu Removal from Solution



Summary

- An electrolytic cell has been designed and the concept of using GNF as an electrode for the removal of metals from aqueous solution has been demonstrated.
- This approach is currently being used to separate other hazardous contaminants.
- The optimum types of GNF for this application appear to be the “herringbone” and “platelet” conformations.
- These structures possess a combination of high surface area and high electrical conductivity.

Future Studies

- We shall use XPS to ascertain the difference in GNF functionalities following treatment in various acid media.
- Attempt to correlate the dramatic differences observed following certain acid treatments of GNF with the functionality of the reactive edge sites.
- Based on this information we should be in a position to tailor the GNF chemistry to obtain maximum adsorption capacity for a given organic impurity molecule.

Acknowledgements

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