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Investigation of carbon materials in energy storage applications by x-ray Raman scattering and optical Raman spectroscopy

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Introduction

Carbon materials are of utmost importance in energy storage applications (Fig. 1). However their structure – performance relationship is poorly understood.

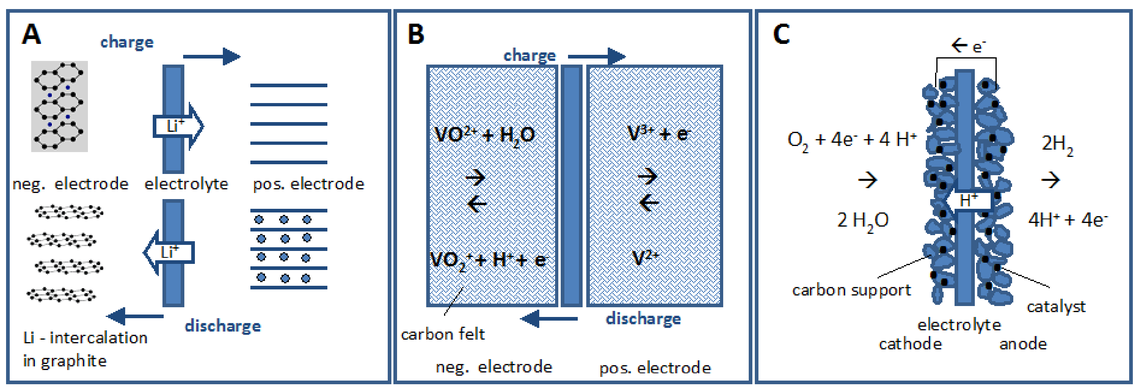

Figure 1. (**A**) Lithium-ion battery with an intercalation electrode. (**B**) Vanadium redox-flow battery and (**C**) H_2/O_2 polymer electrolyte fuel cell. [adapted from Winter et al *Adv. Mater.* **1998** 10(10) p.725-763.]

Results

Materials investigated:

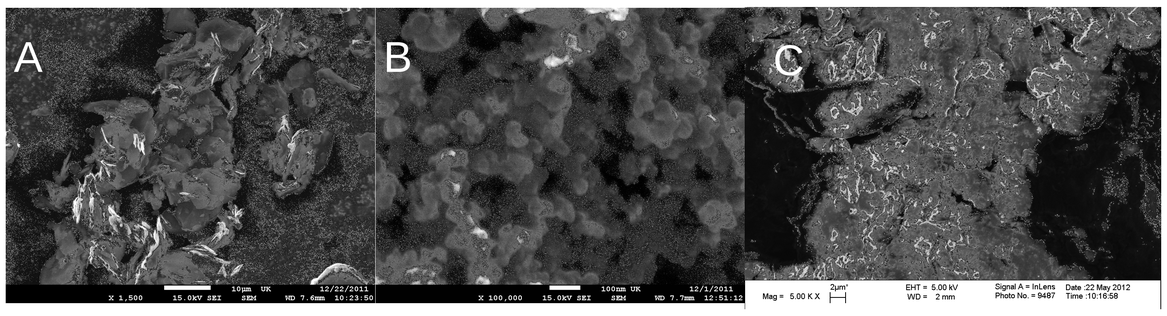

Figure 2. Scanning electron microscopy images of the different samples, graphite (A), Vulcan XC72 (B) and graphite oxide (C)

Disorder obtained by Raman spectroscopy

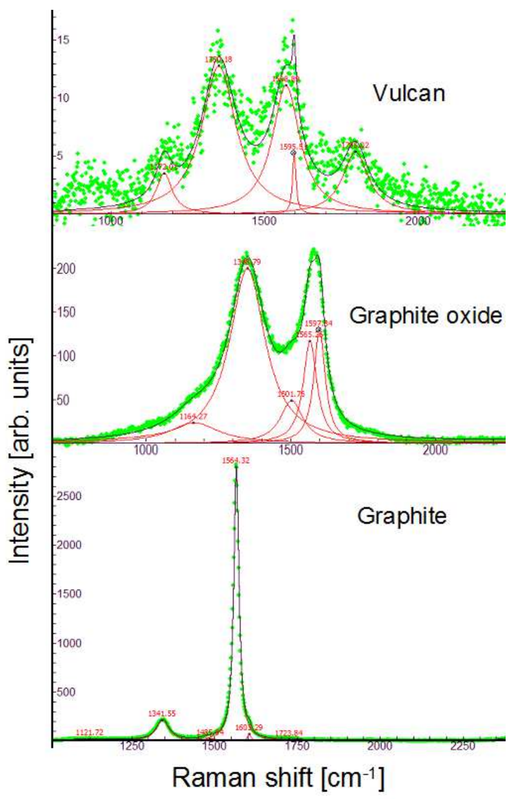

Figure 3. The Raman spectra (λ=514nm) of graphite shows the typical G-band [1580 cm^{-1}] and the disorder induced D-band [1350 cm^{-1}]. These bands are also observed for the other materials but broadened. The peak area ratio D/G determines the disorder in the materials and increases in the following order: Graphite>Vulcan>Graphite oxide (GO).

	D	G	D/G
Graphite	15649	82798	0.2
GO	46685	10619	4.4
Vulcan	2738	2201	1.2

X-ray Absorption Spectroscopy

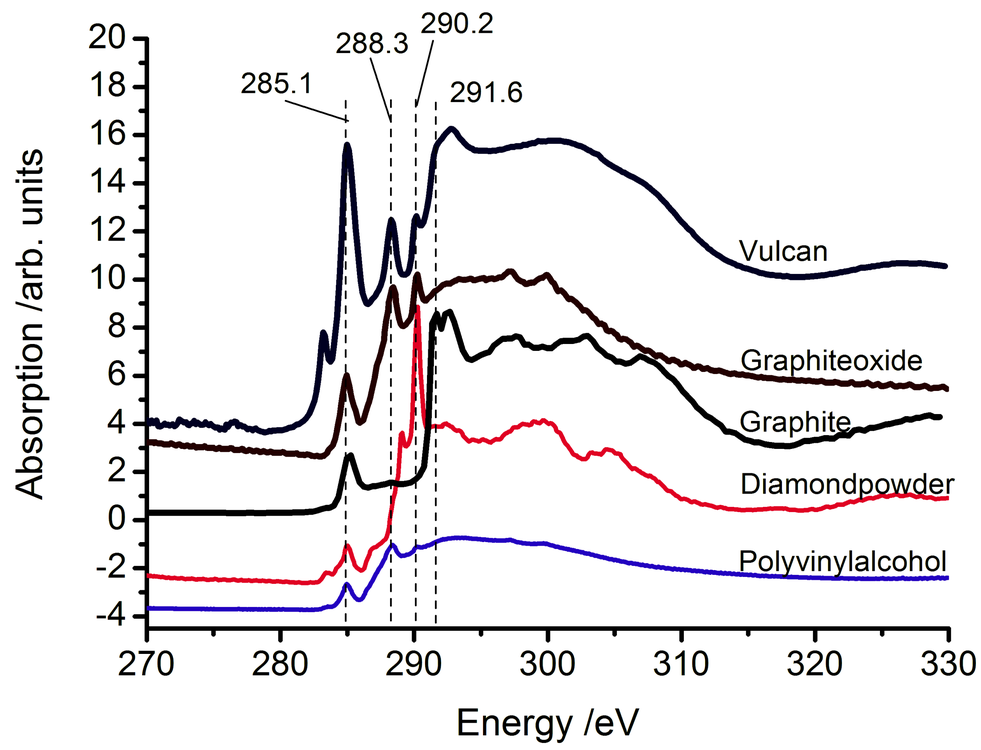

Figure 4. The C-K-edge was measured in TEY. The spectra of carbon black and graphite show the π*-feature at around 285.1 eV and the σ*-feature at around 292 eV as known for graphitic materials. But compared to the nanoparticle graphite the carbon black shows additional features at 288.3 eV which was also found for PVA and at 290 eV which is observed for diamond nanoparticles. This experiment has been done at the SIM Beamline, SLS.

X-ray Raman Scattering (XRS)

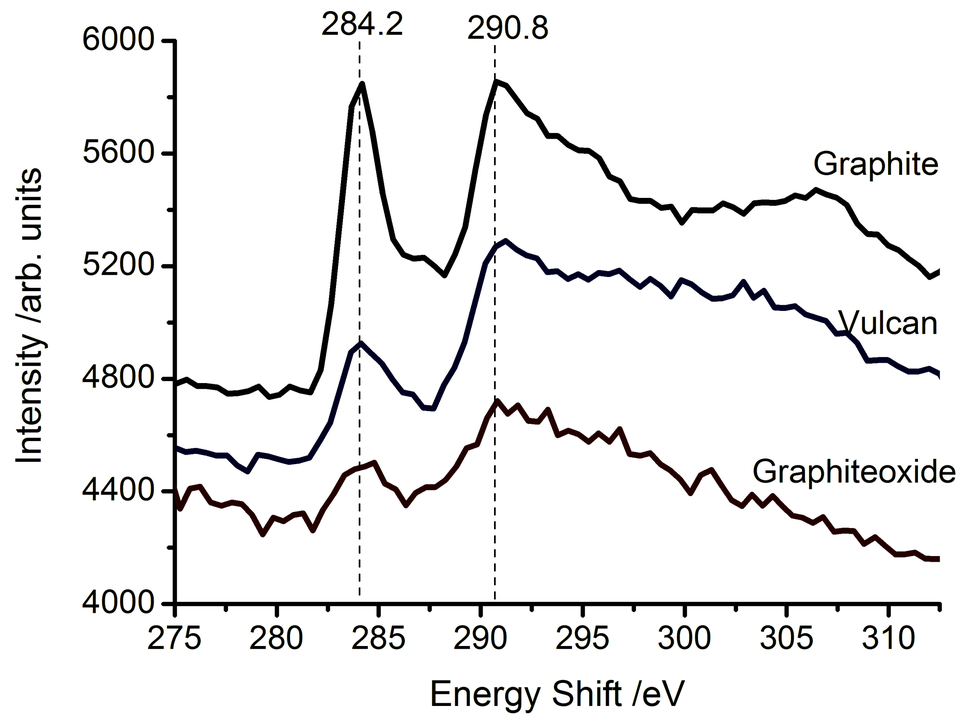

Figure 5. The XRS spectra for graphite, Vulcan and graphite oxide are displayed. All three samples show the π*-feature at 284 and the σ*-feature at around 290 eV. For graphite we found a larger π*-resonance compared with the NEXAFS data. The opposite behaviour is observed for Vulcan whereas the graphite oxide data are similar. X-ray Raman scattering measurement have been performed at the SuperXAS Beamline, SLS using the X-ray emission spectrometer. The scattered X-rays were detected at E_s=8.047 keV while the incident energy E was scanned from 8.322 – 8.36 keV.

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