Micro-CT as a Non-Destructive Tool for Imaging the Uptake of Metal Nanoparticles by Graphene Based 3D Carbon Structures

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S1 Segmentation Procedure

The segmentation procedure undertaken on the X-ray nano-CT images in Figure 8 is progressed in the following way:

1. Apply a 3D 3x3x3 Gaussian Filter
2. Convert the image type from 32-bit to 8-bit
3. Crop the volume to exclude bright artefacts outside volume of interest
4. Labelling:
   a. Simple threshold for NPs (bright) and 1 x volume expansion (1 pixel in all directions)
   b. Simple threshold for C-sponge (light grey) and 3 x volume contraction and expansion
   c. Watershed segmentation based on seeds detailed above

S2 Analysis

S2.1 Full FOV

Volumes and Areas

VSSA = Volume-specific surface area

VISA = Volume-specific interfacial area

Total volume of carbon = 21.3 mm$^3$

Total volume of NPs = 9.7 mm$^3$

Absolute surface area of carbon = 1880 mm$^2$

Absolute surface area of NPs = 670 mm$^2$

VSSA of carbon (/Vol C) = 89 mm$^{-1}$

VSSA of carbon (/Vol Tot Solids) = 61 mm$^{-1}$

VSSA of NPs (/Vol NP) = 68 mm$^{-1}$

S2 Analysis cont.:

VSSA of NPs (/Vol Tot Solids) = 21 mm$^{-1}$

Absolute interfacial area C-NPs = 320 mm$^2$

VISA C-NPs = 10 mm$^{-1}$

Conclusions:

Volume of carbon = 2.2 x Volume of NP

Surface area of carbon = 2.8 x Surface area of NP

VSSA (/C) of carbon = 1.3 x VSSA (/NP) of NP

VSSA (/Tot) of carbon = 2.9 x VSSA (/Tot Solids) of NP

VISA (/Tot) of carbon-NP) = 1/6 of total VSSA of carbon (/Tot) (10 / 61)

S2.2 Sub-volume Porosity estimation

Extracted sub-volume with dimensions: 376 x 306 x 180

Volume of extracted sub-volume 1 = 2.50 mm$^3$

Estimated porosity = 70 %

Volume of extracted sub-volume 2 = 1.38 mm$^3$

Estimated porosity = 77 %

Volume of extracted sub-volume 3 = 1.03 mm$^3$

Estimated porosity = 73 %

Average percentage porosity = (70 + 77 + 73) / 3 = 73 %

Porosity range = 70 - 77 %

Std. deviation = 2.9 %

Conclusion:

Estimated porosity of carbon sponge = 73 ± 3 % (1 s.d. of error)