

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 mm³

Total volume of NPs = 9.7 mm³

Absolute surface area of carbon ≈ 1880 mm²

Absolute surface area of NPs ≈ 670 mm²

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 mm²

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

VSIA (/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 mm³

Estimated porosity = 70 %

Volume of extracted sub-volume 2 = 1.38 mm³

Estimated porosity = 77 %

Volume of extracted sub-volume 3 = 1.03 mm³

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)