SMALL ANGLE X-RAY SCATTERING FROM BROWN COAL

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Small angle X-ray scattering has been widely used in the past to study the structure of porous materials. The interpretation of the scattering data has been usually been in terms of models based upon discrete pores (1). As it is now recognized, such models are inadequate to describe a complex system such as coal and in this paper we propose to interpret the X-ray scattering from brown coal in terms of fractal concepts.

The use of fractals to describe naturally occurring geometric forms (2) has led to the recent introduction of fractal theory to describe the scattering from porous substances. A fractal interface displays self-similarity at different scales. Electron micrographs at different magnifications show that brown coal appears to be predominantly fractal in structure (the exceptions being the occasional large fossilized skeletal remnant). As parameters such as the surface area are not uniquely defined for a fractal interface it is necessary to use more relevant parameters such as the fractal or Hausdorff dimension to characterize a fractal interface. The Hausdorff dimension is a measure of the irregularity of the interface and varies between 2 for a smooth interface to 3 for a rough convoluted interface. Various scattering studies of coal and other porous materials exhibit a power law dependence upon angle and this has been interpreted as being a result of the material's fractal properties. The fractal dimension can be calculated directly from the power law dependence and the extent of the interface can be determined from the intensity of the scattering.

Figures 1 and 2 show the scattering curves for solar dried brown coal slurries which have undergone two different sample preparation procedures. The 1mm thick samples have been embedded in plastic and polished until the coal surface has been exposed. From the best fit to the scattering data in the angular range 0.4 to 6 mrad we have derived values for the Hausdorff dimension of 2.35 and 2.44. This is somewhat lower than the value of 2.56 reported for North America lignite (3) and suggests that the structure of Victorian brown coal is less convoluted and more "graphitic" than North American lignite. It was also found that the intensity of scattering for two samples of compacted solar dried slurries differed by a factor of 10 procedures. This suggests that the extent of the interface differs by approximately 10 even though the Hausdorff dimensionality derived from the scattering curves for the two samples are not markedly different.

The correlation of the measured Hausdorff dimensions with physical properties of coal will be an interesting avenue for exploration in the future.

References

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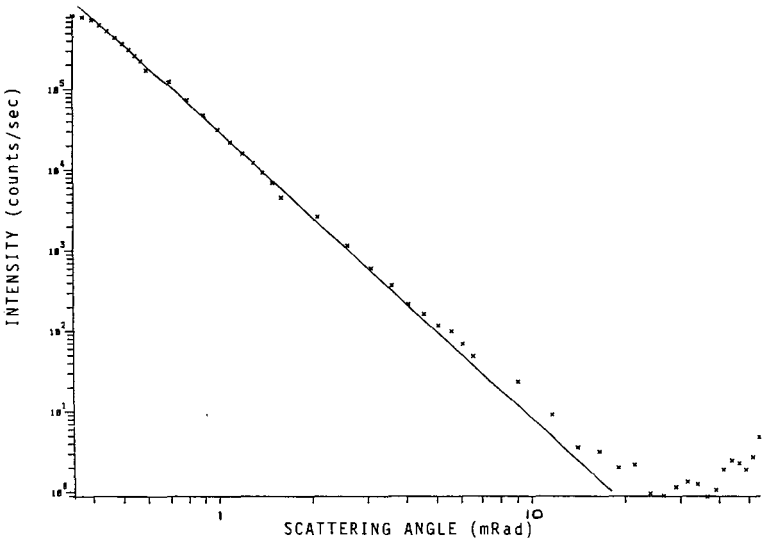

Fig. 1 The scattering curve for ultra-fine ground solar dried coal slurry. The line of best fit corresponds to a Hausdorff dimension of 2.44.

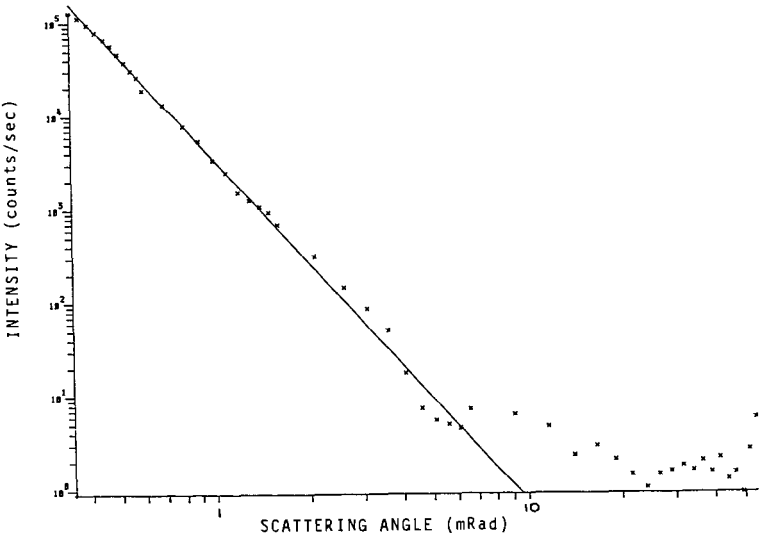

Fig. 2 The scattering curve for alkali-digested solar dried coal slurry. The line of best fit corresponds to a Hausdorff dimension of 2.35.