

Trace Element Distributions of a Granular Activated Carbon

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Various papers in the literature suggest the need for a better understanding of the structure and composition of commercial granular carbons (GAC) with respect to trace elements. There is growing evidence that the trace element composition of a GAC changes during use as an adsorbent in water treatment: accumulation of Al and Si (1) as well as Ca and Cl (2) has been reported, in contrast to loss of Cu (3). In all of these studies, interpretation of the results is dependent on characterization of the original GAC adsorbent, before its use. Most often, trace element composition of a commercial GAC is given from results of ash analyses, but little information is available on trace element distribution or mineralogy in individual grains of the adsorbent.

In this paper, we present elemental distributions determined for samples of a commercial GAC, Calgon F400. This GAC is manufactured from bituminous coal, has a surface area of $\approx 1000 \text{ m}^2/\text{g}$, and is commonly used to adsorb organic contaminants from potable water (4). Samples that we have examined include both virgin and spent Calgon F400. The latter was collected from a pilot column operated for 26 weeks in the potable water treatment plant at Waterford, New York (2,5).

Elemental distributions of GAC samples were obtained by energy dispersive X-ray fluorescence (EDXRF) analysis, combined with scanning electron microscopy (SEM). Concentrations of Al, Si, K, Fe, S, Ca and Cl were sufficiently above EDXRF detection limits, so that their mineral distributions could be examined against the background of continuum fluorescence (6). In order to interpret SEM-EDXRF results for Fe, we have also obtained the Mössbauer spectrum for virgin Calgon F400, following procedures developed for coal and coal products (7-9).

Distributions of Al, Si, Fe and K reveal the presence of large inclusions (10-360 μm) of a clay mineral derived from illite. We also find mineral inclusions (6-80 μ) of Fe alone. These inclusions are considered typical of minerals found in bituminous coals (10,11).

However distributions of other elements indicate that the mineral composition of Calgon F400 is complicated by transformations occurring during its manufacture. Elemental distributions for S are diffuse and do not indicate the presence of iron sulfide compounds, although pyrite is the major iron mineral in bituminous coals (10,11). Moreover, extraction of Calgon F400 in 9% boiling nitric acid removes only 28% of the iron and 12% of the sulfur, although this method is recommended for the extraction of pyrite from bituminous coals (12). The Mössbauer spectrum of virgin Calgon F400 confirms the presence of iron oxides and iron metal as probable products of pyrite during manufacture of the GAC. Semi-quantitative analysis of the spectrum indicates iron is present as 21% hematite-magnetite, 12% metal, 14% pyrrhotite-troilite, and 53% illite-wüstite-pyrite.

In samples of spent Calgon F400, Cl and Ca are characterized by diffuse distributions. Concentrations of these elements, as a function of pilot column bed depth, are highest in GAC samples from the inlet and diminish at points downstream (2). In addition, 80% of the adsorbed Cl is removed from the GAC by heating in a flow of He and steam at temperatures between 100 and 400°C, whereas 91% of the adsorbed Ca is extracted by a solution of 0.1N nitric acid. Results of quantitative EDXRF analysis suggest that the diffuse distributions of Cl and Ca are characteristic of elements associated with compounds adsorbed on the surface of Calgon F400, when used for water treatment.

References

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