Comparison of adsorption properties of Cs on different types of activated carbon

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Cs-137 ($T_{1/2}$ ≈ 30 years) is an important long-term contributor to environmental contamination. It is released into the biosphere by nuclear weapons testing or reactor accidents (Whicker et al., 2007). For example, the release by the accident at the Fukushima Daiichi nuclear power plant raised the Cs-137 concentrations in the local groundwater to concentrations above the drinking water limit in downstream areas like the Fukushima port (TEPCO, 2013). Cs salts are very soluble in water, but strongly bind to soils and minerals (Public Health Service, 2004). These properties are used to investigate the removal of Cs from water using a wide range of low-cost adsorbents (Li et al., 2014).

In order to remove (radio-)caesium from water, adsorption on activated carbon (AC) is suggested as an economical and straightforward method to concentrate low levels of Cs on a compact adsorbent. Considering the high pH point of zero charge of several AC's, adsorption should be performed at high pH (Hanafi, 2010). The goal of this work is to determine the best adsorption conditions for removal of low levels of Cs from radioactive wastewater, using AC. In this experiment, AC's from brewer's spent grain (BSG) are compared to two commercially available industrial AC's. The BSG AC's are produced in a tube reactor using steam activation (Vanreppelen et al., 2014).

A 1000 ppm Cs (σ= 29 barn) standard solution (VWR CertiPur, traceable to NIST) was irradiated in the neutron flux of the BR-1 reactor at SCK-CEN Mol to obtain a Cs-134 solution. From the mother solution, three dilutions with different pH (7, 10 and 12) were prepared, adjusting the pH with ammonia. Dilution factors and concentrations were calculated by measuring the samples in a NaI well detector (nearly 100% efficiency for Cs-134) and in an ionisation chamber. Cs-134 serves as a tracer for the total amount of Cs in the solution and its activity can be correlated to the concentration.

Adsorption experiments are carried out at 3 different pH's using 10 different AC's: 2 commercially available AC's (Norit G1240, Filtrasorb F400), 3 AC's from BSG, and the same 5 AC's previously loaded with a small amount (0,5 %) of Prussian Blue (PB) prior to the adsorption experiment in order to further enhance Cs adsorption. The amount of PB on the AC's is determined by calculating the difference between the iron concentrations (measured via ICP-AES) of a PB solution before and after adsorption of PB on AC. Approximately 25-30 mg of AC is put into contact with 9 g of the active Cs solution (±1.2 ppm Cs; 0.6 Bq/g) and the total activity is determined by measuring the tubes in the NaI well. These tubes are shaken for 36 hours. The solution is filtered using plastic funnels and Whatman ashless filters to separate the AC from the solution. The emptied tubes, the filters with AC and the tubes with the collected solutions are measured in the NaI well. From the measurement, the fraction of Cs-134 adsorbed on the AC and the fraction remaining in the solution are calculated.

As shown in figure 1, adsorption percentages between 15 and 20 % are reached for both commercially available AC's and lab-scale AC's from BSG at pH 12. The highest adsorption rate was reached using the AC from BSG (activated with steam at 800 °C for 45 minutes with 10 ml of water (ACBSG07)), with an adsorption capacity of 18,6 % (no loading) and 20,3% (loaded with PB).

Adsorption of Cs at low levels in water is feasible using AC as adsorbent. Modification of the AC for optimal adsorption of Cs can be considered, as well as purification of Cs contaminated water in sequential adsorption stages.

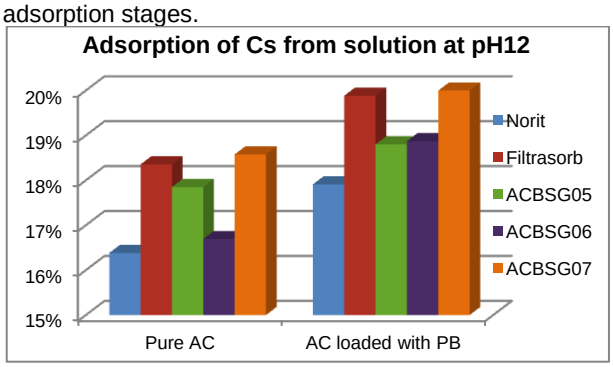

Figure 1. Adsorption percentage at pH 12.

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