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**Supplementary File**

# Adsorption of radiocesium from aqueous solution using chemically modified pine cone powder*

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## Methods

### *Bulk density determination*

Bulk density measurement was carried out in a 25 $cm^3$ density bottle. The dry PCP was added to the weighed density bottle with gentle tapping to ensure that the particles settle to the bottom and all air spaces are filled. The mass of PCP which occupies 25 $cm^3$ volume = (mass of bottle + pine cone powder) – mass of empty bottle.

Bulk density = Mass of PCP occupying 25 $cm^3$ volume/ 25 $cm^3$ (1)

### *Surface negative charge*

One-half gram of PCP, which had pH values < 3.0, was suspended in 25 $cm^3$ of 0.10 $mol/dm^3$ NaOH and stirred at 300 rpm between 16 and 20 h in a 100 $cm^3$glass stoppered Erlenmeyer flasks. The flasks were kept stoppered during stirring to minimize the dissolution of carbon dioxide gas in the NaOH and the subsequent formation of $Na_2CO_3$. The flask contents were filtered by vacuum filtration through Whatman #4 filter paper and 10 $cm^3$ of the filtrate added to

15.0 $cm^3$ of 0.10 mol/$dm^3$ HCl. The addition of excess HCl prevented any possible adsorption of carbon dioxide by the base and was particularly important if the solutions were required to stand for extended time periods before analysis. The solution was titrated with 0.10 mol/$dm^3$ NaOH until an endpoint. The results were expressed in mmoles $H^+$ neutralized by excess $OH^-$ per gram of pine cone powder.

***Brunauer–Emmett–Teller (BET) Surface area***

The Brunauer–Emmett–Teller (BET) surface area and pore size distribution were determined using computer-controlled nitrogen gas adsorption analyzer. Degassing was carried out for 1 h at 90 °C and increased to 120 °C for 2 h. A mass of 0.2 g of raw pine cone and toluene-ethanol modified PCP was applied for analysis.

***X-Ray Diffraction (XRD)***

XRD measurements were conducted to identify the chemical composition and crystallographic structure of the raw and modified PCP. XRD patterns were obtained with an X'Pert PRO X-ray diffractometer (PANalytical, PW3040/60 XRD; CuKα anode; $\lambda$ = 0.154 nm). The samples were gently consolidated in an aluminium holder and scanned at 45 kV and 40 mA from 10° to 120° $2\theta$ the exposure time for each sample was 20 min and a step size of 0.02°. The diffraction patterns were analyzed using X'Pert High Score software (version 2.2.0) and plotted using OriginPro 7.0.