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Technology Offer

Decontamination of radioactive caesium in humans

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Prof. Klaus-Richard Pörschke and co-workers from the MPI for Coal Research developed a highly hydrophobic perfluoroaryl borate (FAB) ligand for trapping the radioative 134/137 Cs isotopes with 100% specificity. The novel approach could improve the decontamination of humans compared to the administration of so called insouble Prussian blue currently in use.

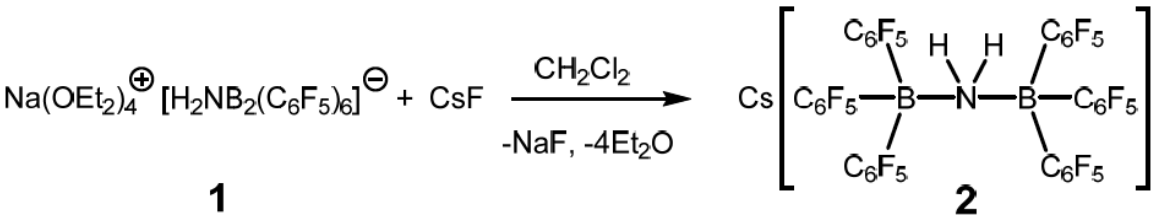
Background

The uncontrolled emission of radioactive isotopes of the Cs atom (especially ^{134}Cs and ^{137}Cs) following for instance accidents in nuclear power plants causes serious and long-term effects on environment, humans and animals. The ^{137}Cs isotope, in particular, has long half-life ($t_{1/2}$= 30.2 years) and a very high solubility in water that causes a rapid widespread distribution in the body.

The currently used remedy for the decontamination of humans and animals involves the administration of a blue colored complex of ferric hexacyanoferrate (II) with the empirical formula of $Fe_4[Fe(CN)_6]_3$, also known as *insoluble Prussian blue* (PB). PB absorbs efficiently the $^{135/137}Cs^+$ ions, both with respect to binding strength and absorption rate, without being absorbed by the bowels to a noticeable extent. The retention time of the ^{137}Cs isotope in the human body following the therapy with PB is reduced by about 2/3 in adults and by about half in adolescents and children. However chemical physical factors such as pH, moisture content, drying and storage conditions, can impact the efficiency of cesium binding to PB.

Technology

The present technology utilizes the highly hydrophobic perfluoroaryl borate (FAB) ligand of (**1**) for trapping the $^{134/137}$Cs isotopes with 100% specificity.



Related ligands are $Cs[B(C_6F_5)_4]$ (**3**) and $(H_2O)B(C_6F_5)_3$ (**4**); the latter ligand forming $Cs[H(HO)_2B_2(C_6F_5)_6]$ (**5**) in the presence of Cs^+ ions.
The complex $^{135/137}Cs[H_2NB_2(C_6F_5)_6]$ (**2**) precipitates or can be extracted quantitatively from water (dielectric constant 78.4) or acidic solutions containing the $^{135/137}Cs^+$ ions in concentration as low as a few ppm. Complex formation for (**1**) and (**3**) are independent from pH in aqueous solution allowing efficient binding all through the pH window encountered along the gastrointestinal tract in humans. Complex (**5**) is slightly more water-soluble and pH dependent, but is formed from ligand (**3**) which is easier to prepare and cheaper to produce.

All compounds **1**–**5** appear indefinitely stable in the solid state, which for **1–3** and **5** is also true in solution. No composition occurred on the laboratory scale. Concerning $B(C_6F_5)_3$ or **4** in aqueous solution, slow decomposition in the long run (over months) cannot be excluded.

Compound (**1**) can be synthesized easily by reacting 2 equivalents of $B(C_6F_5)_3$ in a suspension of sodium amide in diethyl ether to obtain a colorless crystal in high yield.

The ligands (**1**) and (**3**) could be administrated in the form crystalline solids of sodium salts, e.g., as solvates in polyethylene glycol 400 (PEG 400) or other glycols. However toxicological studies were not yet performed.

Advantages:

- Perfluoroaryl borate (FAB) ligands are highly specific for cesium ions and insoluble in water based solutions
- Cesium complexes formed with FAB ligands are independent from the pH of the water based solution

Patent Information

Priority application EP2016159522 filed on 09.03.2016
EP2017710178, AP/P2018010989, AU2017230853, CA3015721, EA201892546, IN201817033737, US16/083043 currently under examination.

Literature

David Pollak, Richard Goddard, Klaus-Richard Pörschke: "$Cs[H_2NB_2(C_6F_5)_6]$ Featuring an Unequivocal 16-Coordinate Cation", *J. Am. Chem. Soc.* 2016, **138**, 9444−9451

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