

## Task 15

# Immobilization of Fission Iodine by Reaction with a Fullerene Containing Carbon Compound and Insoluble Natural Matrix

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## BACKGROUND

The recovery of iodine released during the processing of used nuclear fuel poses a significant challenge to the transmutation of nuclear waste. Iodine-129, a long-lived fission product formed by both commercial nuclear power generation and nuclear weapons production, is released when reprocessing nuclear fuel. Since iodine can be concentrated in the human thyroid, any uncontrolled release of iodine may result in an increased rate of thyroid cancer in the exposed population. For this reason, recovery of iodine is important for implementing any nuclear transmutation strategy.

The first step in any transmutation strategy is the processing of the used nuclear fuel. This step involves separating the used fuel into its constituent elemental components, allowing the recovery of the uranium, actinides, long-lived fission products, and other components, depending on the strategy and processes involved.

When used fuel rods are dissolved in concentrated nitric acid in preparation for actinide recovery, iodine is released from the fuel. A significant fraction of the iodine is lost to the vapor phase during this process, where it may potentially become a fugitive emission and be released from the plant. To avoid this, specialized filtration systems are used to try to trap and sequester the released iodine (and other fission product gases).

The primary goal of this research is to capture and immobilize the iodine released from these processes in a form that can easily be converted to a suitable target for neutron-induced transmutation. The investigators believe that iodine released during fuel reprocessing can be immobilized in a Fullerene Containing Carbon (FCC) compound or a Natural Organic Matter (NOM) matrix.

Natural organic matter (such as sphagnum moss, peat or brown coal) is an inexpensive and a renewable resource. Further processing of the trapped iodine using simple desorption or

combustion processes should be able to produce iodine in a form suitable for transmutation. Furthermore, collaborators at the Khlopin Radium Institute (KRI) have proposed that the iodine-loaded FCC material, when combined with ceramics, is stable enough for use as a long-term storage form, and may be usable as a transmuter target matrix.

## RESEARCH OBJECTIVES AND METHODS

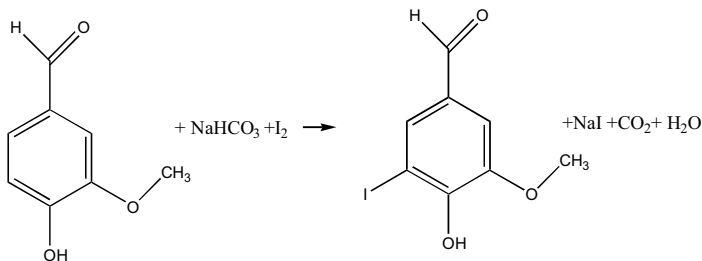
The stability of the association of iodine with FCC and NOM products are studied. Product distributions for the various matrices under various reaction conditions were examined in order to maximize the binding of iodine. The recovery of the iodine from the sequestration matrices was also examined, along with the conversion of the iodine to matrices more suitable for geological storage and/or use as transmutation targets.

The following are the specific research objectives and goals:

- Develop bench-scale experimental set-up and procedures for simulating PUREX head-end vapor phase.
- Develop experimental procedures for evaluating iodine sequestering methods using bench-scale procedures.
- Develop FCC bearing material as potential iodine sequestration matrix.
- Determine binding of iodine to FCC and NOM.
- Examine alternate iodine sequestration matrices using techniques developed for FCC and NOM studies.
- Examine the effect of reaction conditions on binding.
- Elucidate the nature of the reaction products (volatile, hydrophobic, soluble, insoluble).
- Develop methodology and host matrix for converting sequestered iodine to solid matrix for evaluation as transmutation target and/or disposal matrix.
- Examine recovery of iodine from sequestration matrices.

The FCC compounds are developed and prepared by the KRI Research Industrial Enterprise (KIRSI). The KRI-KIRSI team research the impacts of process parameters on sorption of iodine, and examine the material properties, such as how iodine attaches to the FCC compounds. The KRI-KIRSI team also examines the conversion of the iodine loaded FCC compound to a stabilized matrix (similar to ceramic) for potential use as a disposal form, acceptable transportation material, or potential target material.

UNLV examines the FCC material, along with NOM and other potential sequestering agents, under simulated process conditions. Both teams examine the recovery of the iodine from the sequestering matrices.

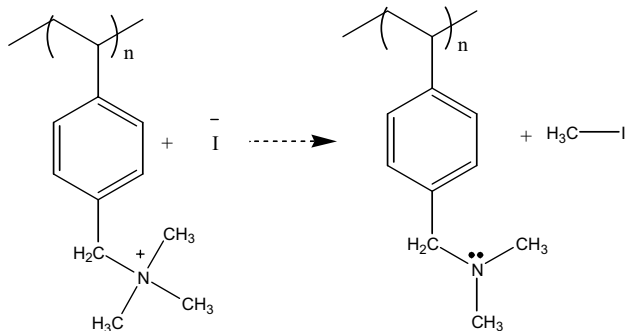


*Ring addition of iodine to a phenolic compound. This reaction is an analogy for reaction with NOM.*

## RESEARCH ACCOMPLISHMENTS

Highlights of accomplishments to date include the following:

- Different NOM materials and FCC materials have been characterized.
- Iodine uptake experiments on NOM and FCC have been conducted and indicate favorable sequestration by NOM and favorable adsorption by FCC.
- The iodine vapor generator assembly was completed. Experimental results indicate that iodine can be trapped on FCC or NOM. Tests of iodine sequestration/adsorption



*Transformation of iodide to methyl iodide by pyrolysis of anion exchange resin.*



*Iodine System*

were conducted with a commercial peat moss and the results indicated sorption and non-reversible sequestration occur. For FCC adsorption reversible sorption was observed.

- Ion chromatography, gas chromatography/mass spectroscopy, electrochemical and colorimetric methods to separate various iodine species were tested.
- A number of experiments have been conducted with alkali lignin and sphagnum moss to study iodide binding. The iodinated materials have been examined by pyrolysis. Researchers have discovered that pyrolysis releases the bound iodide as methyl iodide. Pyrolysis of FCC releases elemental iodine.
- The alkali stability of several model organic iodides was studied to see if base promoted hydrolysis will be useful in concentrating iodine from NOM
- The transfer of iodide to organic matter as facilitated by the chlorine sulfonamide resins was examined. Using NOM analogs, iodine was shown to become associated with organic matter in the presence of the active chlorine sulfonamide resins.
- The conversion of iodine to iodate during fuel rod dissolution experiments with FCC has been documented.
- The reduction of iodate to iodide by reaction with NOM has been investigated.
- The trapping of iodide in several anion exchange resins has been examined. The release of iodine and methyl iodide during pyrolysis of these resins has also been investigated.

## FUTURE WORK

Trials with NOM will be continued in the third year of the project. Additional sequestration experiments with the fuel rod simulator will be performed. Investigation into the speciation of iodine in the NOM in an exposed trap will be continued. Additionally, rate constants for the formation of iodate and for the formation of iodophenols will be estimated. The effect of pH on the reaction of iodine with NOM will continue to be investigated. Conversion of trapped iodide (via methyl iodide) to potential target materials will be studied and a bench scale method will be developed.

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