**Extraction and seperation of TRITIUM, THE NucleAR FUSION FUEL and the BY-PRODUCT OF FISSION**

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, Tritium, denoted as 3H or T is a beta-emitting radioactive isotope of hydrogenproduced in very small quantities in the atmosphere as a result of cosmic radiation induced nuclear transmutations [1] Tritium is proimarly produced by ternary fission in nuclear weapon tests and nuclear power reactors (yield ranged between 0.01–0.02%) by neutron activation reactions with boron in water and control rods:

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| --- | --- |
| *10B+n→3H+4He+4He* | (1) |

Large commercial nuclear power reactors produce about ~2 g of T per year generally incorporated in the nuclear fuel and cladding leading to the permeation of T in the spent fuel, construction materials and coolant [2]. In CANDU type fission reactors tritium is generated through the reaction of fission neutrons with the heavy water moderator and coolant [3]. In nuclear fusion processes, as alternative to alternative to conventional sources, T, safer and more effective approach of nuclear energy harnessing, it is used as a nuclear fuel and is being produced on site from lithium according to:

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| --- | --- |
| 6Li+ n*→3H+4He* | (2) |

Tritium that has been produced in the fission reactors as a by-product, therefore, could be extracted and used as a fuel in the nuclear fission reactors.

It must be pointed out that T has also commercial applications in industrial thickness gauges, luminous paints, watch dials, radioactive tracers for chemical, biological and environmental studies.

There is a constant risk of T release into the environment from the nuclear facilities such as pressurized water reactors, irradiated fuel and recycling plants and based on T production during waste dispose, small incidents or nuclear accidents such as as the case of Fukushima Daiichi that caused significant emission of T into the environment[4]. It must be also emphasized that T can replace normal hydrogen (protium) in chemical compounds essential for life, and is very mobile within the physical and biological environments [5].

Tritium separation is crucial in following applications:

* Extraction of T from air in case of industrial contamination in case of containment fails resulting in T emissions (nuclear industry, production plants, research institutions);
* T extraction from cooling water of nuclear fission and fusion reactors in order to decrease amount and class of radioactive wastes [6];
* T recovery and purification for its further use in fusion devices or industrial applications as mentioned above;
* decrease of T contamination in natural water sources in case of accidental ®tritium water leakages;

Existing methods for T separation are mostly either time and energy consuming or expensive. New separation methods with larger separation factors, reduced number of stages and energy consumption are needed. Moreover, a mobile, remote controlled device capable to operate in harsh environments could be of great importance in case of nuclear/radiation accidents.

An alternative approach for hydrogen separation is proposed by Hidalgo et al [7]. Method is based on technique using graphene based – electrochemical pumping. Electrochemical pumping applies fuel cell principle – the membrane-electrode assembly consists of two catalytic electrodes deposited on a proton conducting membrane. Hydrogen gas or water is split on one side to the proton and electron, which recombines on the other side of the membrane. NAFION® (sulfonated tetrafluoroethylene based copolymer) is used as the proton exchange membrane coated with graphene layer. Authors suggest that proposed technique could reach the separation factor ~30 for protium-tritium separation that is significant improvement compared to the existing methods [7]. It has been reported in the previous studies that graphene monolayers of graphene can be also \ used for the separation of hydrogen isotopes. It was determined during these studies that deuterons may permeate through two-dimensional graphene crystals much slower compared to that of an protons, resulting in a separation factor of ≈10 at room temperature. The isotope effect is assumed to be attributed to a difference of ≈60 milli–electron volts between zero-point energies of incident protons and deuterons, which translates into the equivalent difference in the activation barriers posed by two-dimensional crystals. Graphene membrane serves simultaneously as a semi-transparent hydron barrier and a drain electrode for proton and deuteron [8]. Currently, there is no experimental data on application for tritium.

The present study reports of the development of a set-up for separation of tritium both from water and gas based on the concept described above. Additionally, special attention is dedicated to evaluation of the radiation stability of the developed system, thus choice of radiation stabile materials and test under potential exposure conditions is discussed in this study.

Proposed alternative is expected to be more cost effective and more durable for the application in harsh environments. Moreover, proposed device can be **automatized and used remotely** that must be emphasized of special importance in radiation environments.

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