Advanced Polymer Composite for Radioactive Waste Containment

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REAL LIFE SITUATION

In 2009, the Emirates Nuclear Energy Corporation (ENEC) was launched as a step into providing clean, safe and efficient nuclear energy in the UAE. As oil reserves decline, ENEC aims to satisfy about 25% of the energy demand of the UAE by 2020. For this purpose, initial drilling for the set-up of four nuclear reactors in *Barakah*, a site west of Abu Dhabi, was started in 2010. However, nuclear energy brings along with it the problem of nuclear waste and with current methods of nuclear waste disposal in geological facilities being expensive, and in some cases, leakage of radioactivity from these disposal facilities was recorded. An alternative cheap, safe, and efficient waste disposal facility is required to ensure the stability of energy generation, to ensure the safety of the environments.

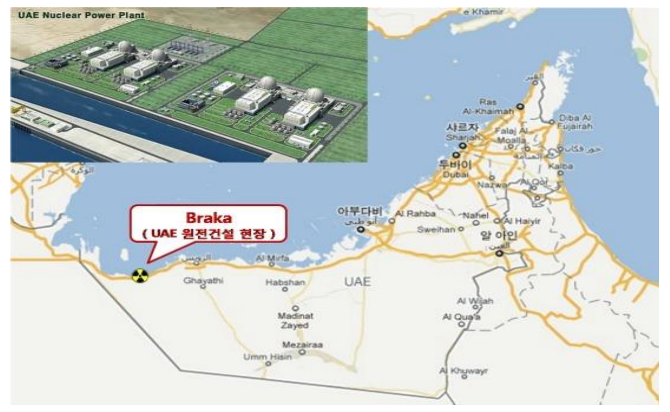


Figure 1: Plant Location [1]

PROBLEM STATEMENT

Geological disposal is the currently accepted method of nuclear waste disposal. However, there are many problems with the current method:

- Cost: the current disposal facilities consumes about $ 1 million per ton of waste, and about 1,000-2,000 tons of wastes are produced annually.
- Space: Sites such as the proposed one in Korea is 2.1 km^2. As large as Monaco
- Leakage: The only waste disposal site in the United States, New Mexico had radiation leaks in 2014.

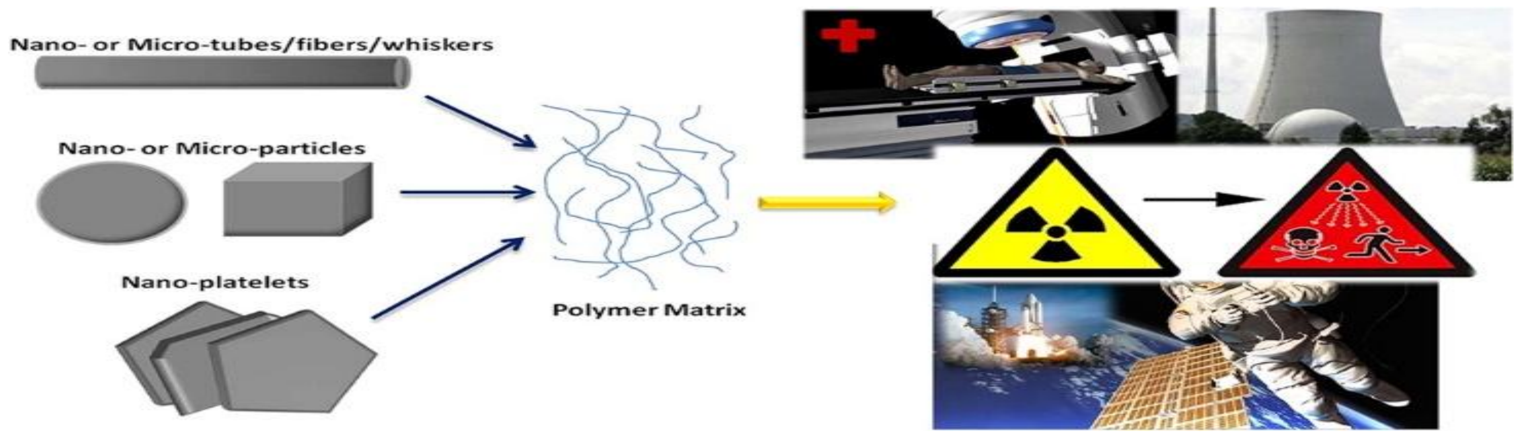


Figure 2: Project Summary [2]

MAIN OBJECTIVES

The purpose of this research project is to come up with a new, relatively cheap, and safe nuclear waste disposal method. This method uses composite polymers to build a container that can block radiation emitted from the wastes.

We aim to identify different types of polymers that satisfy this purpose. Also, we aim to study their expected life, and long radiation effect on the structure of these polymers.

Also, it is crucial to identify what types of radiation that can be blocked by each polymer layer.

Finally, we want to study the different additives that will further serve in blocking, or attenuating the radiation emitted from wastes

PROPOSED SOLUTION

Polymer matrix composites of nanotubes / nanoparticle have shown excellent radiation shielding. Different types of composites can resist different types of radiation. We aim to design a multi-layer polymer that can block waste from nuclear wastes. However, such a solution has not been studied or tested before. The polymer composites that we aim to use are:

- Ultra high Molecular Wight poly ethylene (UHMWPE) reinforced with Carbon Bromide (B_4C) and Tungsten (W) [3].
- Epoxy Reinforced with Iodide bromide (IBr) [2].
- Poly Vinyl Di-Floride reinforced (PVDF) with nanoclay [2].
- Poly (Urethane Carbonate) (PCU) [4].

The Proposed testing mechanism is:

- Design the polymer container in the specified order.
- Put the Container in a canister, specially designed to block any radiation that may leak from the container.
- Equip the canister with different radiation sensor.
- If the container are efficient, the sensors will not record anything. If they are not, radiation will leak, but it will be blocked by the efficient canister.

Polymer	Additive	Advantages	Effective for	Life
UHMWPE	B_4C-W	Scatters radiation within the matrix	122 KeV γ– Fast Neutrons	500 yr.
Epoxy	IBr	Corrosion Resistance	13 KeV X-Rays-46.5 Kev γ	-
PVDF	4 wt % (30 B)	Radiation resistance.	Up to 122 MeV Radiation	-
PCU	None	High radiation stability. (up to 1100 kGy)	1.58e13 Bq radiation	300 yr.
Polystyrene	Into concrete	Increases concrete's radiation resistance	Severe radiation resistance	-

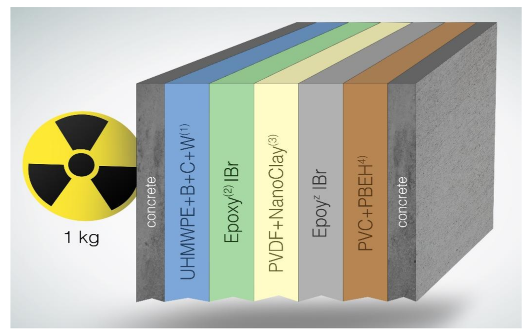


Figure 5: Container Design

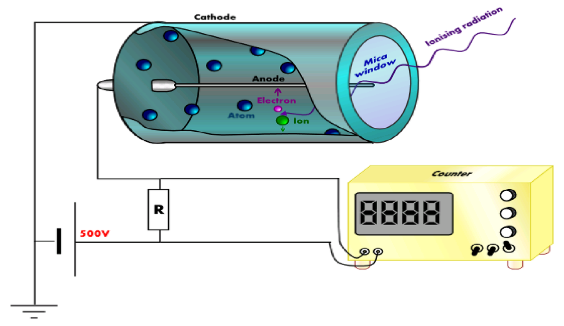


Figure 6: Radiation Sensor [5]

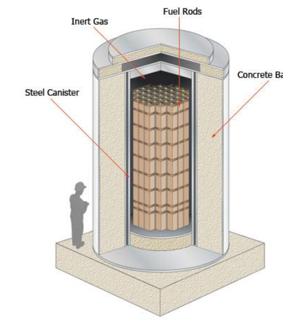


Figure 7: Cask [6]

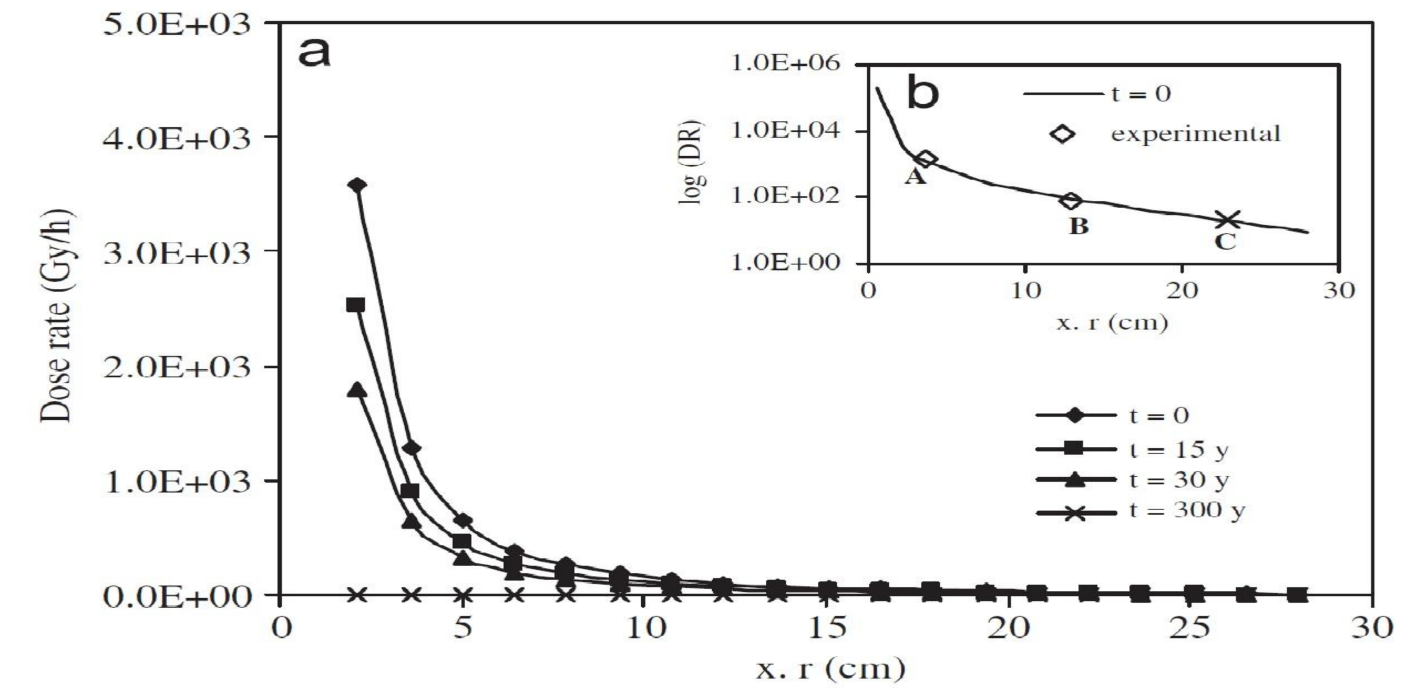
EVALUATION OF COST

Initially the total cost of the project is from:

- Radiation Monitoring: 10 scintillator detector ($200 each) + 10 Geiger counter (gas filled) (50 $ each) 10 Gamma radiation counters ($300 each) + Surface radiation monitors ($15,000). [7]
- Insulated Heavy Duty Industrial Cables will cost $ 41,500 [8]
- The Cask that will contain the radiation (if polymers fails) costs $ 500,000. [9]
- For the Polymer, the research shows that they are way far less expensive than the steel and lead used in the current geological disposal facilities.

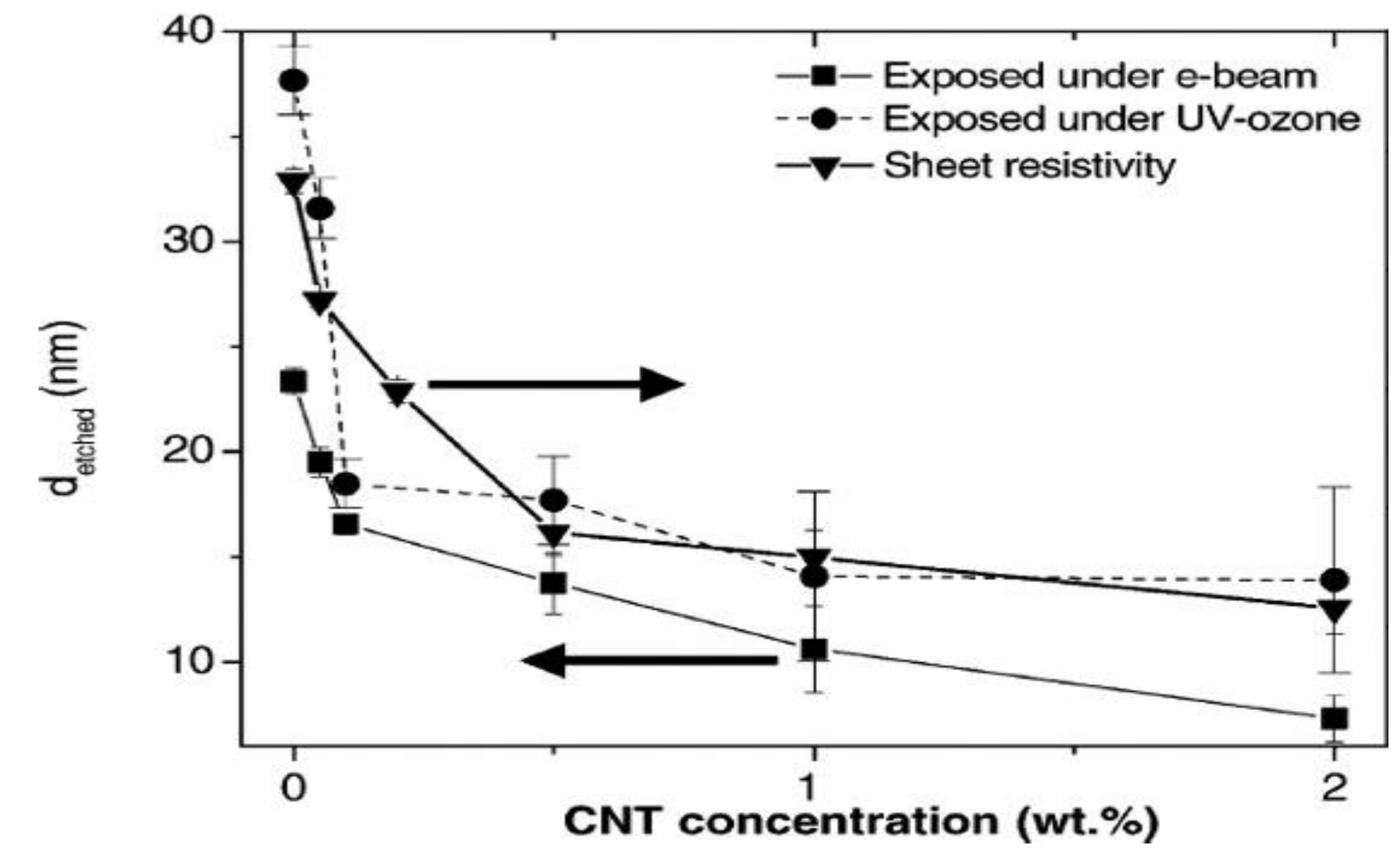
If the polymer container proved to be effective, then neither the radiation monitoring nor the cask will be needed, and it will be used on a wide range at a relatively low cost.

RESULTS ANALYSIS



Radiation Rate vs. Polymer thickness [5]

As the graph shows, the shielding ability of PCU increases with the increased thickness of the polymer. The dose rate reaches zero outside a spherical container of PCU of radius = 30 cm. Simulation was done to anticipate the polymer behavior after 15, 30, 300 years.



Etched Distance vs. CNT Concentration[5]

This graph shows that the Distance in Polymethyl methacrylate penetrated by different types of radiations decreases with increasing the Carbon nanotube contents.

REFERENCE LIST

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