Current status of technology for collection of uranium from seawater

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Uranium Resource in Seawater

One ton of seawater → Uranium 0.0033g (3.3mg)

4.5 billion tons in seawater (1,000times of mine uranium)

Resources with Japan current 5.2×10^6 t/y —~0.2%→ Demand of Japan in a year 8×10^3 t/y

Current state of uranium collection from seawater.

- Adsorbent synthesis: High affinity against uranium in seawater
- Demonstration of uranium collection: Marine experiment
- Cost estimation and Future planning

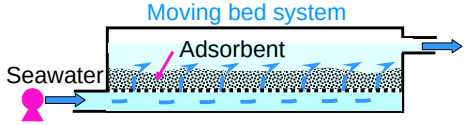
Uranium Adsorbent

~1960 Hydrous titanium oxide adsorbent

Inorganic material

Pumping for preventing adsorbent from sinking

Moving bed system



Pumping → Costly process

Low mechanical strength

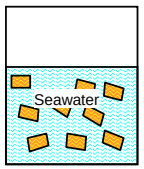
Radiation induced graft polymerization

~1980 Amidoxime adsorbent -C=N-OH | NH_2

Organic polymer

Density is close to that of seawater

No agitation

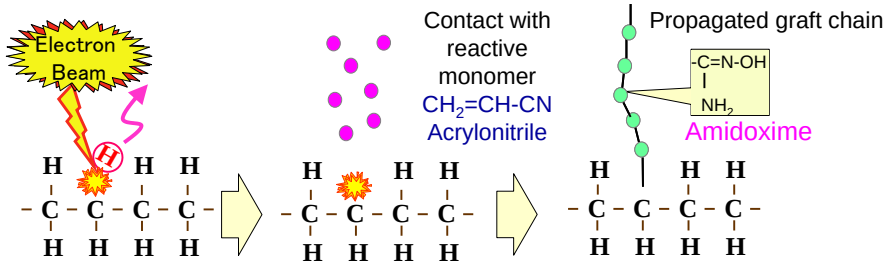


Effective contact by tide and wave motion

Expecting cost reduction

Radiation-induced Graft Polymerization

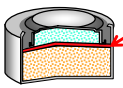
Imparting desired functional group into trunk polymer



Polyethylene
High mechanical strength

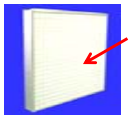
Uranium adsorbent

Industrial applications of graft polymerization



Electro conductive diaphragm membrane

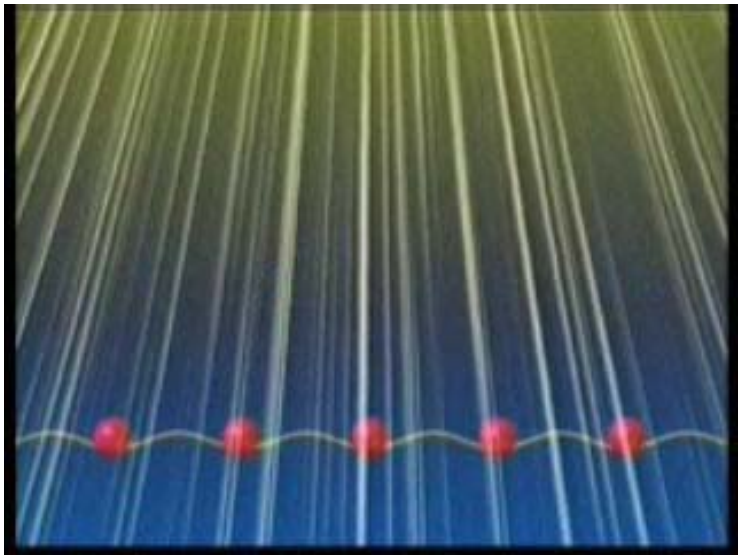
Button shaped buttery



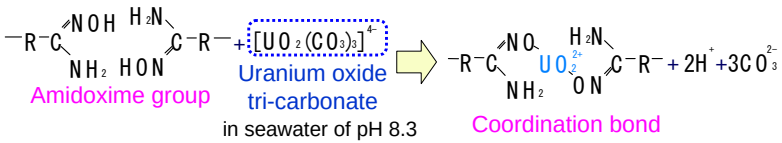
NH_3 gas adsorbent for semiconductor factory

Air purification filter

Image of Radiation induced Grafting



Characteristic of Amidoxime Adsorbent

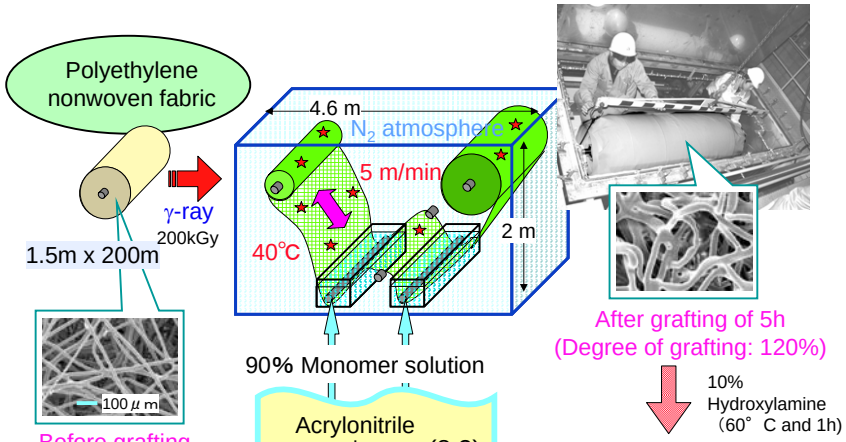


Selectivity of amidoxime adsorbent

Elements	Concentration in seawater[a] [μg/L]	Concentration in adsorbent[b] [μg/g-ad]	Distribution coefficient (b/1000a)
Na	1.08×10^{7}	618.5	0.057
K	3.80×10^{5}	45.9	0.12
Al	2	86.94	4.35×10^{3}
Pb	0.03	108.82	3.62×10^{6}
Ti	1	1.49	1.49×10^{3}
Fe	2	414.44	2.07×10^{5}
Co	0.05	23.57	4.71×10^{5}
Ni	1.7	78.17	4.60×10^{4}
U	3.2	63.72	1.99×10^{4}

Adsorption conditions:0.2g adsorbent 25℃、3L/min seawater, and 7 days.

Mass Production of Adsorbent Fabric

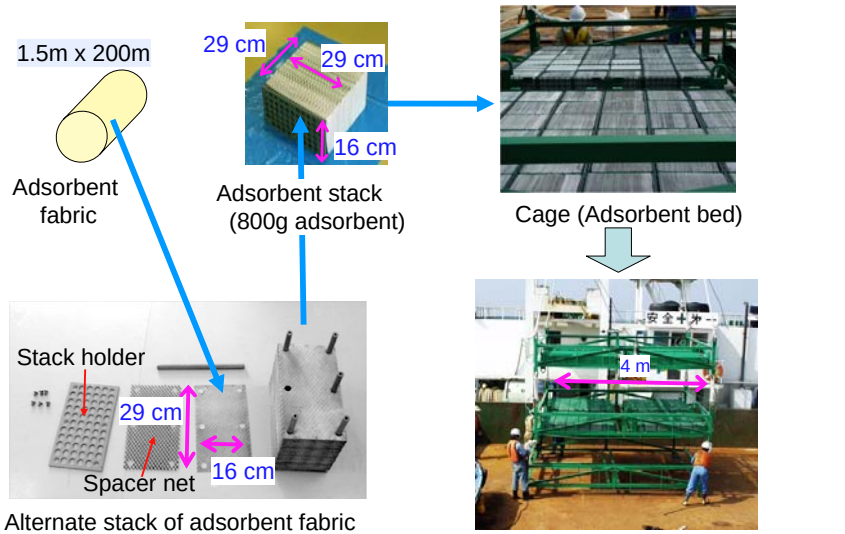


Adsorbent Fabric

6,000 m² (700kg)

1.5m x 4,000m

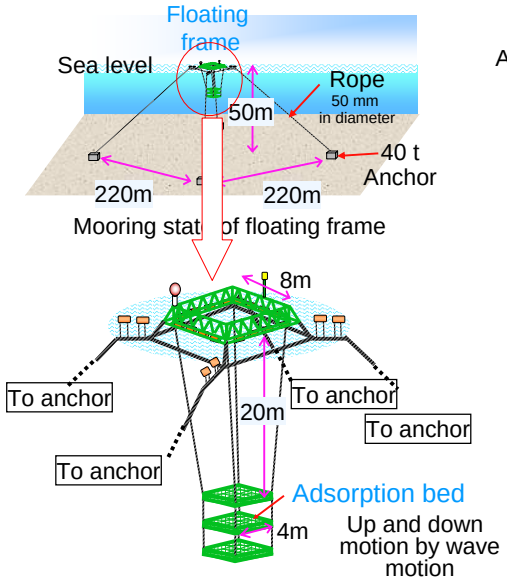
Adsorbent fabric stacks and cages

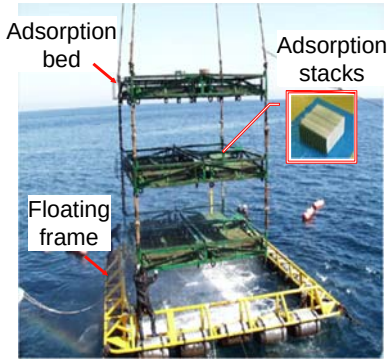


Alternate stack of adsorbent fabric and spacer net (120 stacks)

144 stacks (115 kg) in an adsorbent bed → 432 stacks in three adsorbent beds

Marine equipment for uranium recovery





Drawing up of adsorption bed packed with adsorbent stacks at northern sea in Japan

(350 kg in three adsorbent beds)

Lifting of adsorbent stacks in Marine Experiment

Demonstration of uranium collection

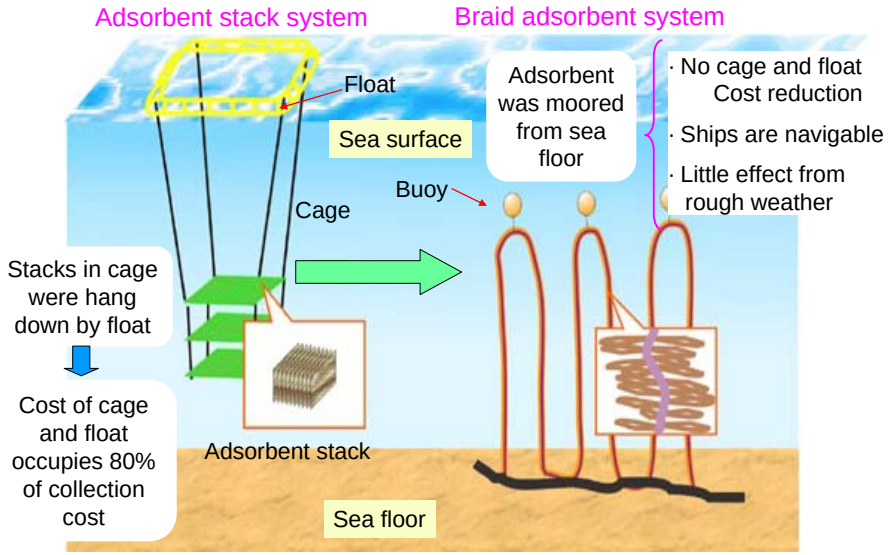
Adsorption stacks → Fractional Elution of Uranium by dilute acid → Purification Solvent extraction → Uranium (Yellow cake)

Submersion period	Submersion days	Seawater temperature [° C]	Number of stacks	Adsorbed uranium [g]
1999 29 Sep.-20 Oct.	21	19 - 21	144	66
2000 8 Jun.-28 Jun.	20	12 - 13	144	47
28 Jun.-8 Aug.	40	13 - 22	144	66
8 Aug.-7 Sep.	29	20 - 24	144	101
7 Sep.-28 Sep	21	24 - 22	144	76
28 Sep.-19 Oct.	21	20 - 18	144	77
2001 15 Jun.-17 Jul.	32	13 - 18	216	95
18 Jul.-20 Aug.	32	18 - 20	216	119
15 Jun.-20 Aug.	65	13 - 20	72	48
20 Aug.-21 Sep.	31	20 - 19	216	118
18 Jul.-21 Sep	63	18 - 19	144	150
15 Jun.- 21 Sep.	96	13 - 19	72	120
				1083

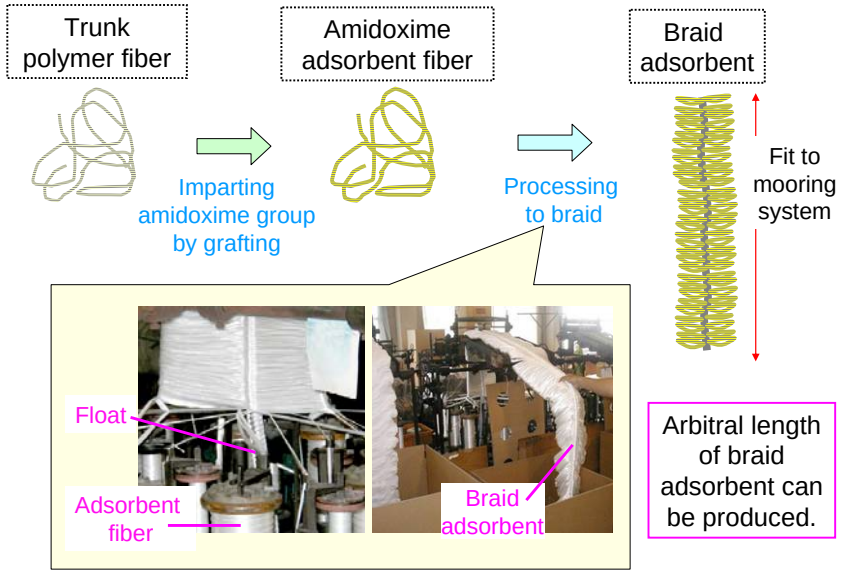
The factors which affect the uranium adsorption were the temperature of seawater and the average height of significant wave.

Purified yellow cake made of uranium from seawater

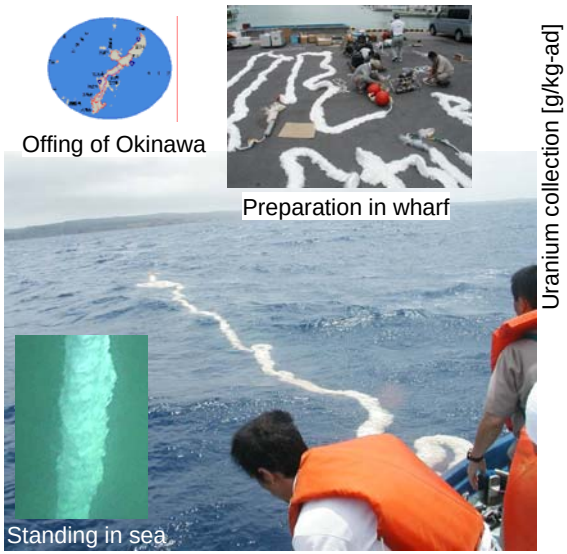
New collection system for cost reduction



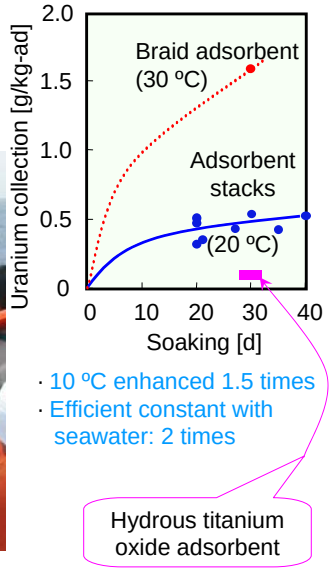
Production of braid type adsorbent



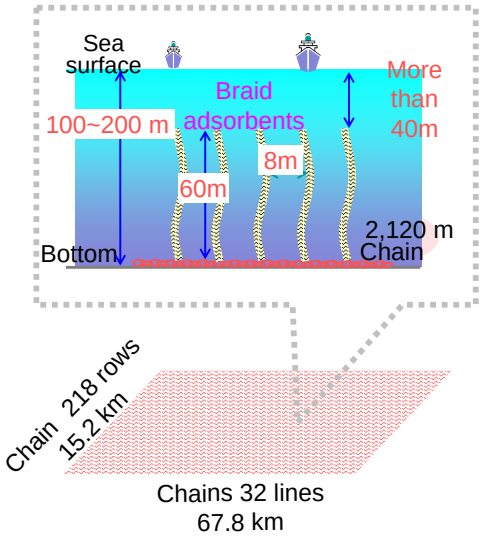
Marine Experiment for Braid Adsorbent

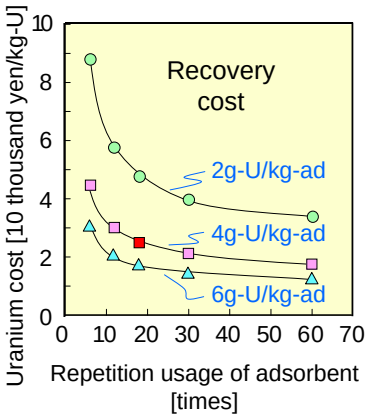


Recovery operation of adsorbent



Cost estimating for 1200 t uranium in a year





- Weekly spot price \$50/lb-U_3O_8 at May, 2009 is 12,000 yen/kg-U.
- Promising collection cost is 25,000 yen/kg-U. This price is twice of spot price.

Conclusions

Adsorbent synthesis

Radiation-induced graft polymerization cloud realize uranium adsorbent which has enough high mechanical strength for mooring and 15 times higher adsorption performance.

Demonstration of uranium collection

One kg of uranium as yellow cake was collected by marine experiment using graft adsorbent.

Cost estimation

Expecting collection cost is 25,000 yen/kg-U which is twice of weekly spot price \$48/lb-U_3O_8 at August, 2009 spot price.

Future planning

- To confirm the number of repetition usage of adsorbent in adsorption and elution of uranium.
- To improve the adsorbent ability.

Thank you for your attention.

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