Synthesis and Characterization of Templated Ion Exchange Resins for the Selective Complexation of Actinide Ions

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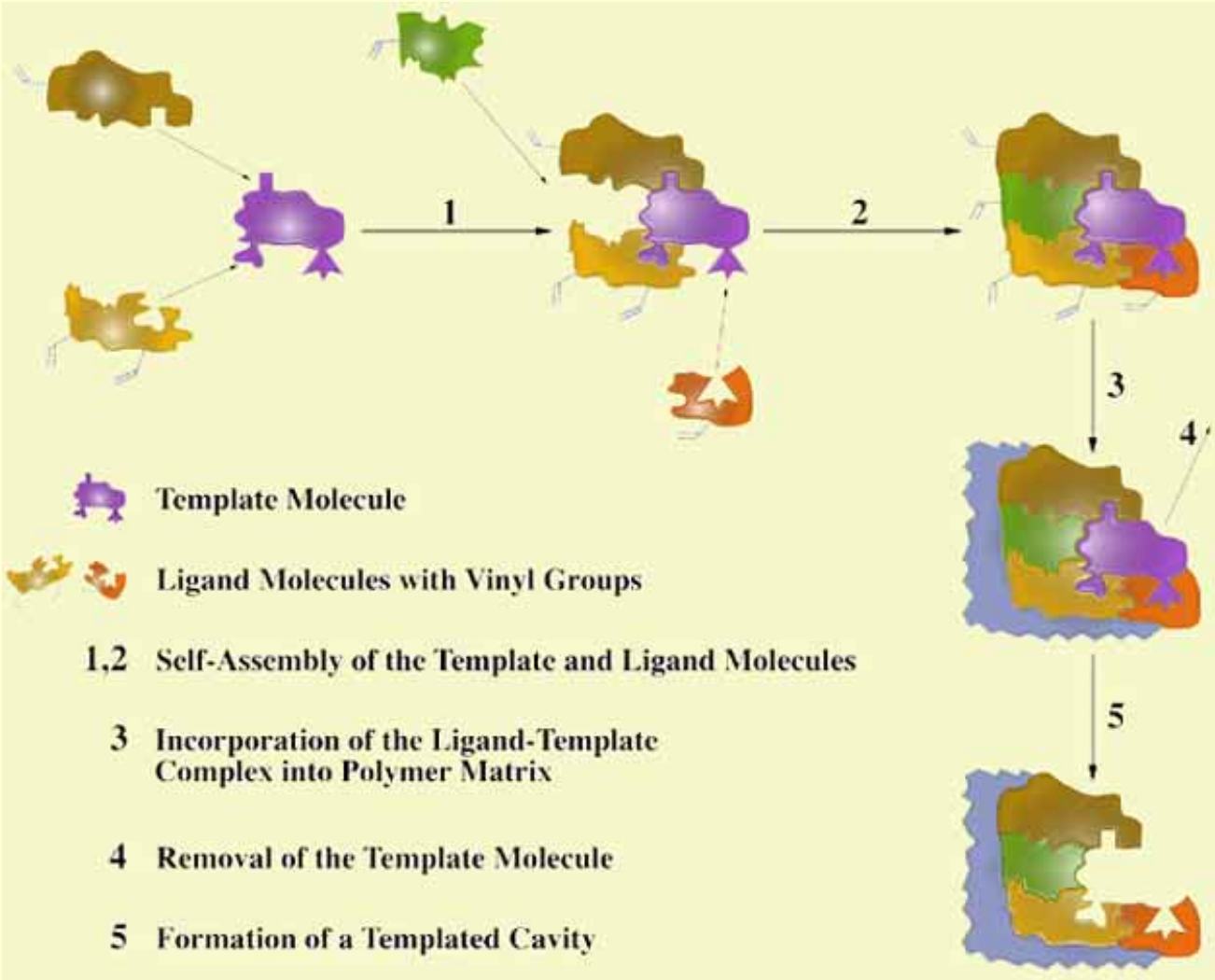
Abstract

The purpose of this research is to develop a polymeric extractant for the selective complexation of uranyl ions (and subsequently other actinyl and actinide ions) from aqueous solutions (lakes, streams, waste tanks and body fluids). Selectivity for a specific actinide ion is obtained by providing the polymers with cavities lined with complexing ligands so arranged as to match the charge, coordination number, coordination geometry, and size of the actinide metal ion. These cavity-containing polymers are produced by using a specific actinide ion (or surrogate) as a template around which monomeric complexing ligands are polymerized. The polymers provide useful sequestering agents for removing actinide ions from wastes, and form the basis for a variety of analytical techniques for actinide determinations.

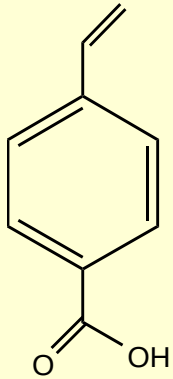
Molecular Imprinting



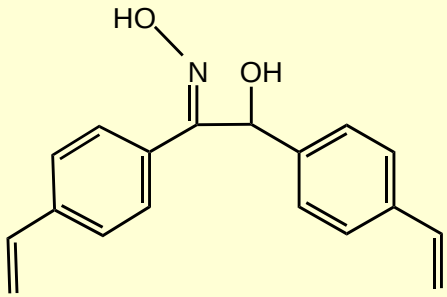
Key Steps in Imprinted Polymer Synthesis

- Organic ligand monomer synthesis
- Metal-ligand complex formation
- Copolymerization
- Imprinted cavity formation

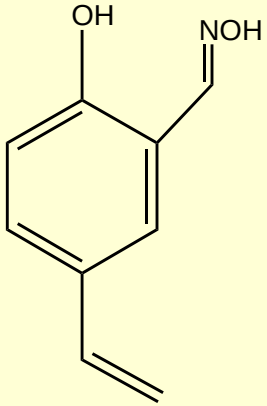
Ligand Monomers



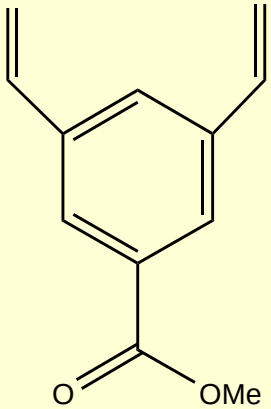
(a)



(b)



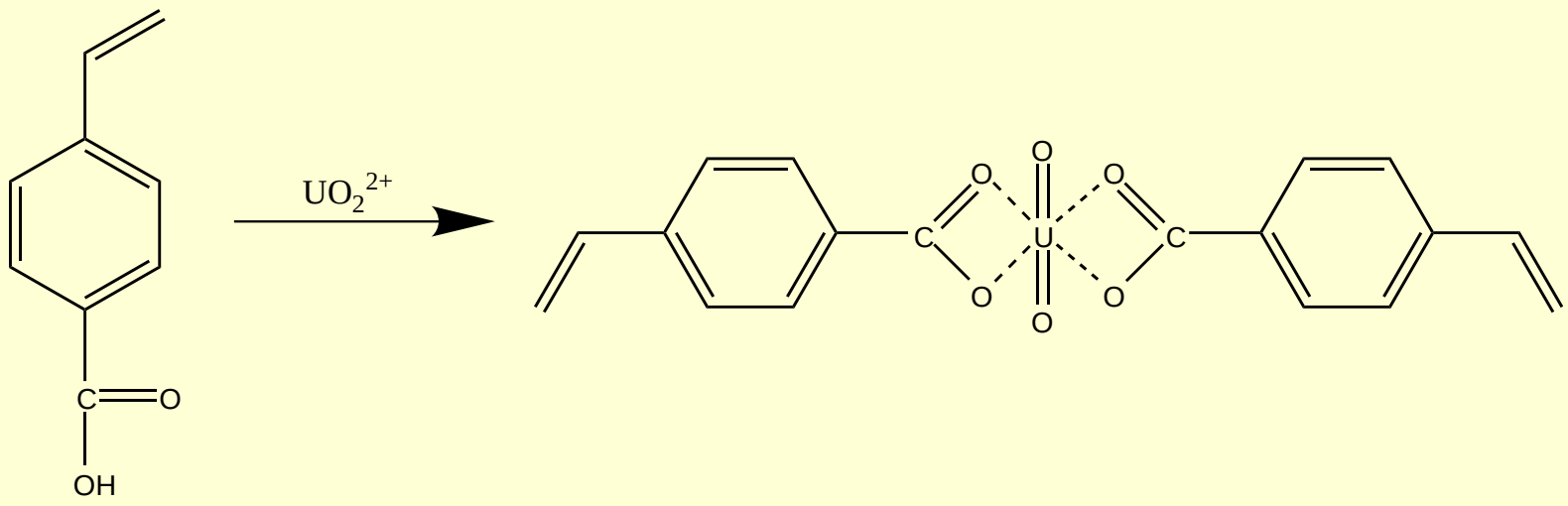
(c)



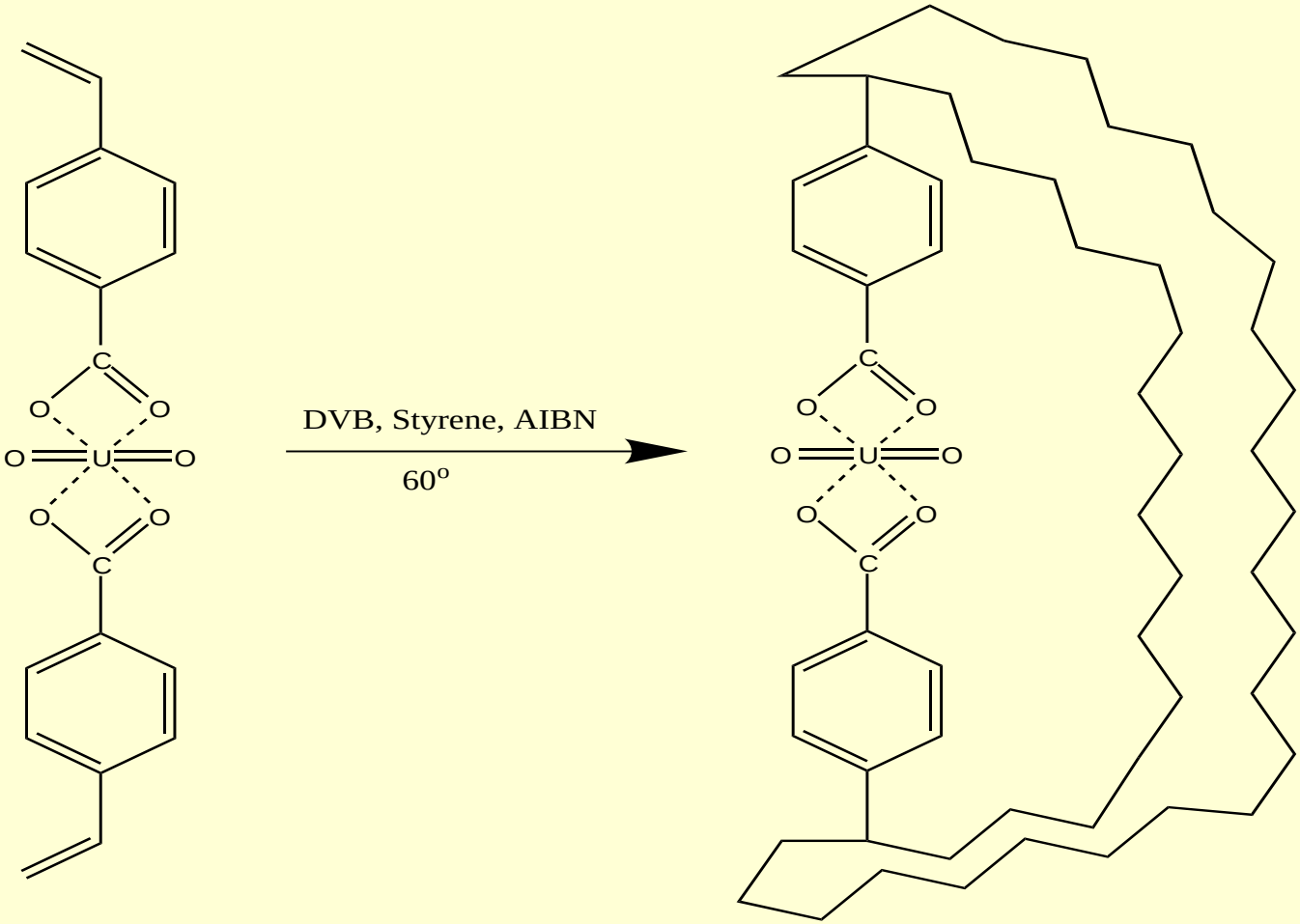
(d)

(a) 4-vinyl benzoic acid (VBA);
(b) 2-hydroxy-1,2-di-4-vinylphenylethanone (divinylbenzoin oxime)
(c) 4-vinyl-2-hydroxybenzaldehyde oxime (Vinylsalicylaldoxime)
(d) methyl-3,5-divinyl benzoate (MDVB)

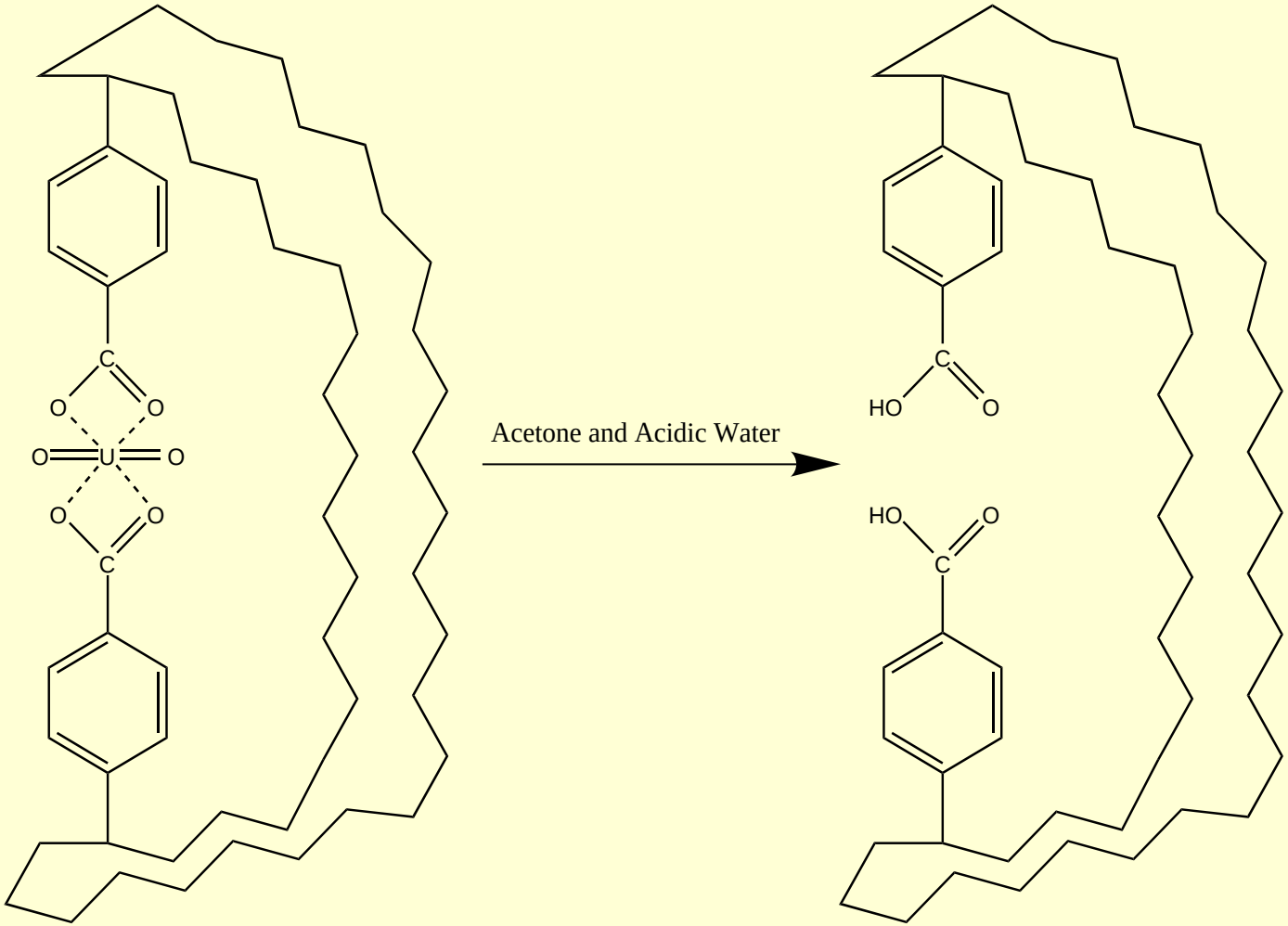
Metal-Ligand Complex Formation



Copolymerization



Imprinted Cavity Formation



Effect of Crosslinking on the Capacity of the Benzoate Resins

Polymer ID	Complex mole%	DVB mole%	Capacity (μmol/g)
U 3-0.5*	3	0.5	0.010
U 3-1 *	3	1	0.009
U 3-2 *	3	2	0.240

* Sonicated for 4hrs

Effects of Sonication on the Capacity of the Benzoate Resins

Polymer ID	Complex mole%	DVB mole%	Capacity (μmol/g)
52U#	1	1.7	0.0239
54U#	1	3.4	0.0275
U1.5-1*	1.5	1	0.0159
U 5-2*	5	2	0.0162

* Sonicated for 4hrs

mineral bath

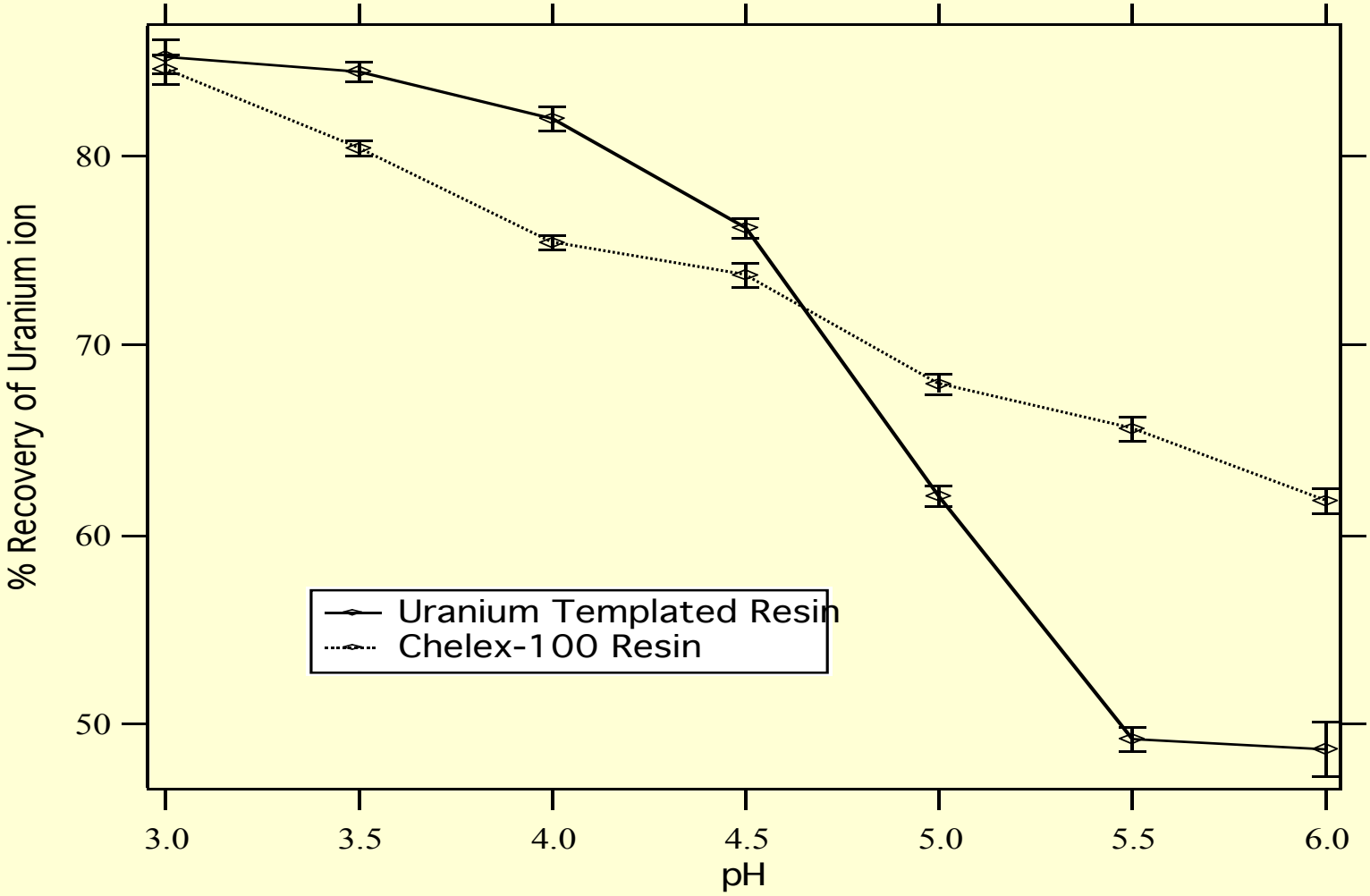
Effects of Crosslinking and Sonication on the Capacity of the Oxime Resins

Polymer ID	Complex mol %	DVB mol %	Capacity (μmol/g)
52Ox U*	1	1.7	0.1535
54Ox U*	1	3.4	0.2388
52Ox U#	1	1.7	0.0277
54Ox U#	1	3.4	0.0547

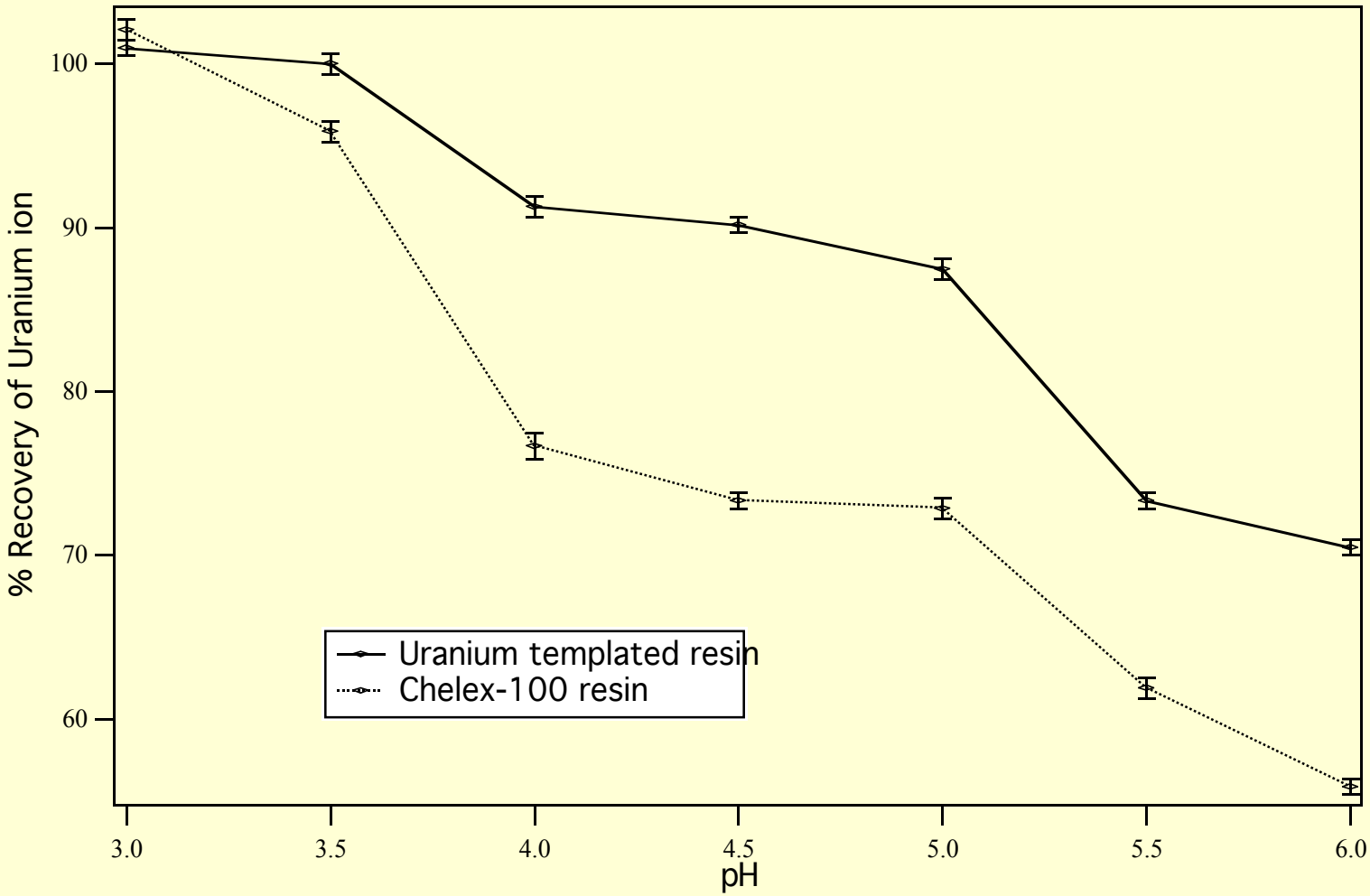
*sonicated for 4hrs

mineral bath

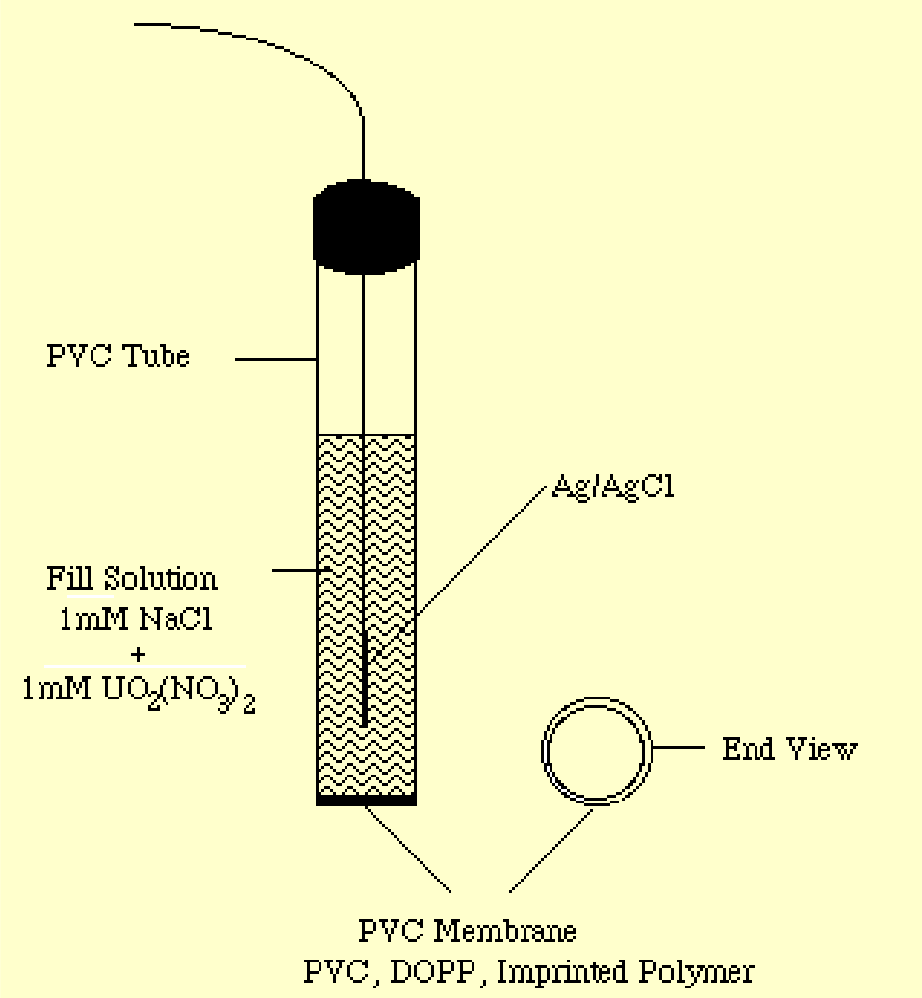
Recovery of Uranium from Tap Water Using the Benzoate Resin Compared to Chelex-100



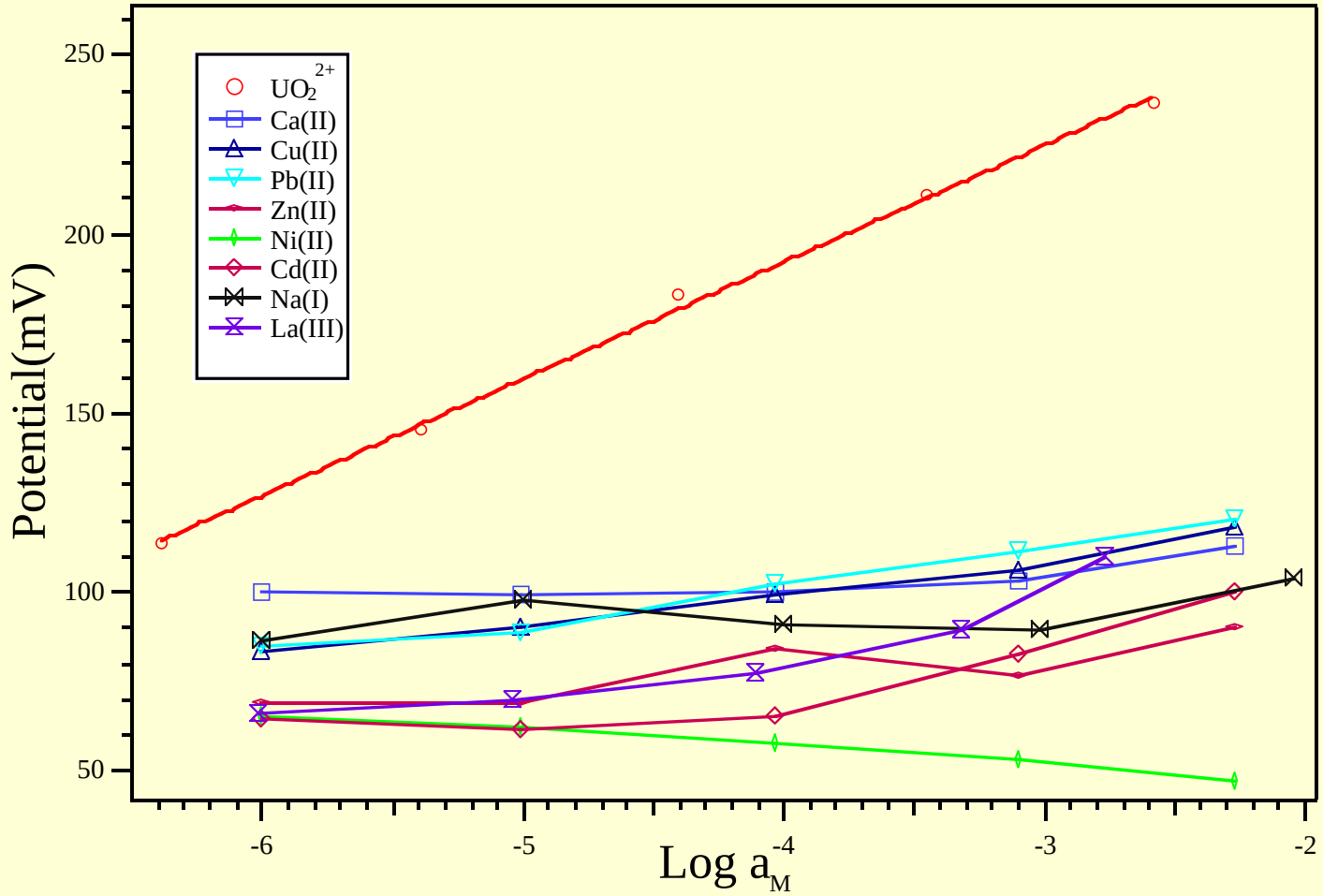
Recovery of Uranium from Sea Water Using Benzoate Resin as Compared to Chelex-100



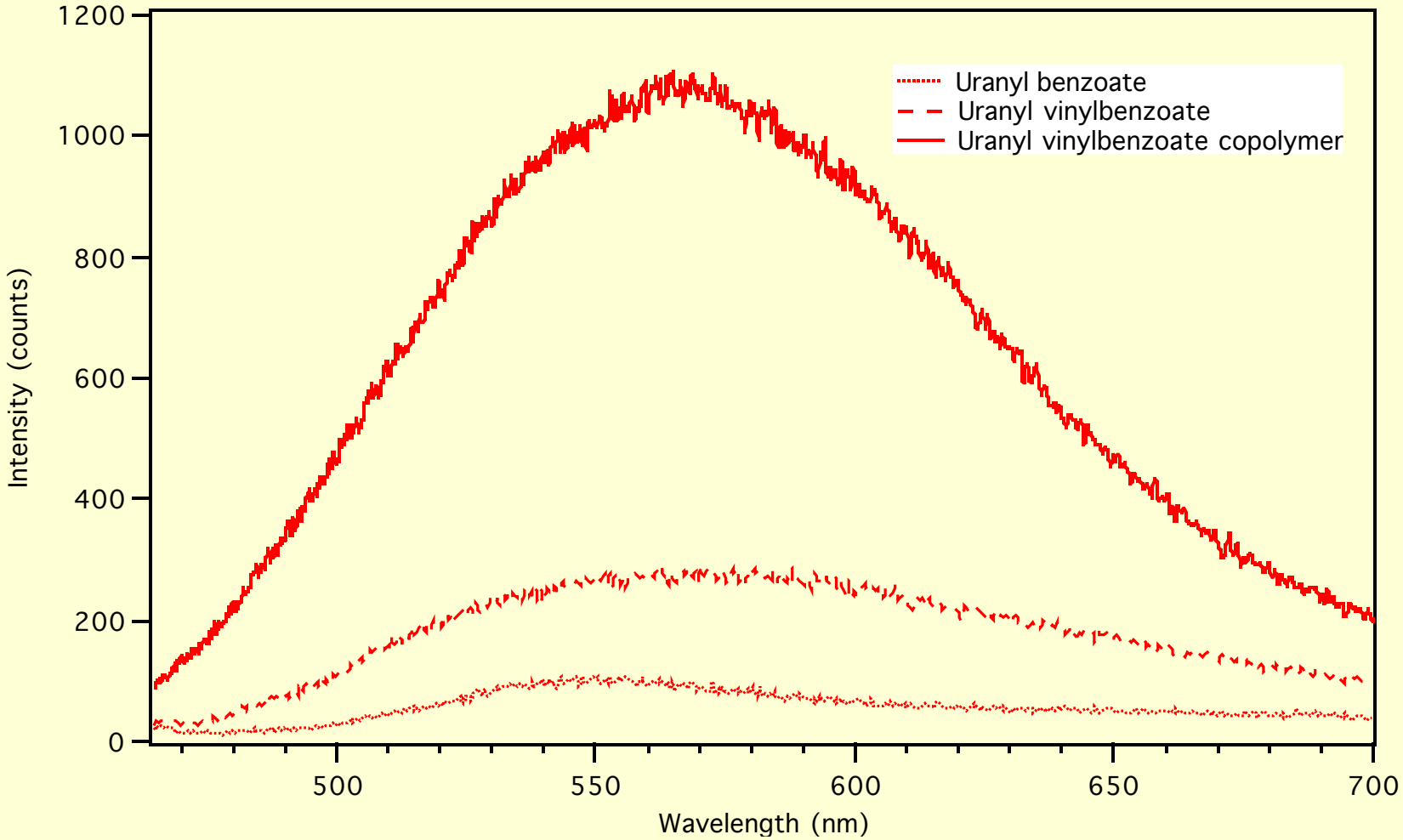
Uranium Ion Selective Electrode Based on the Imprinted Polymer



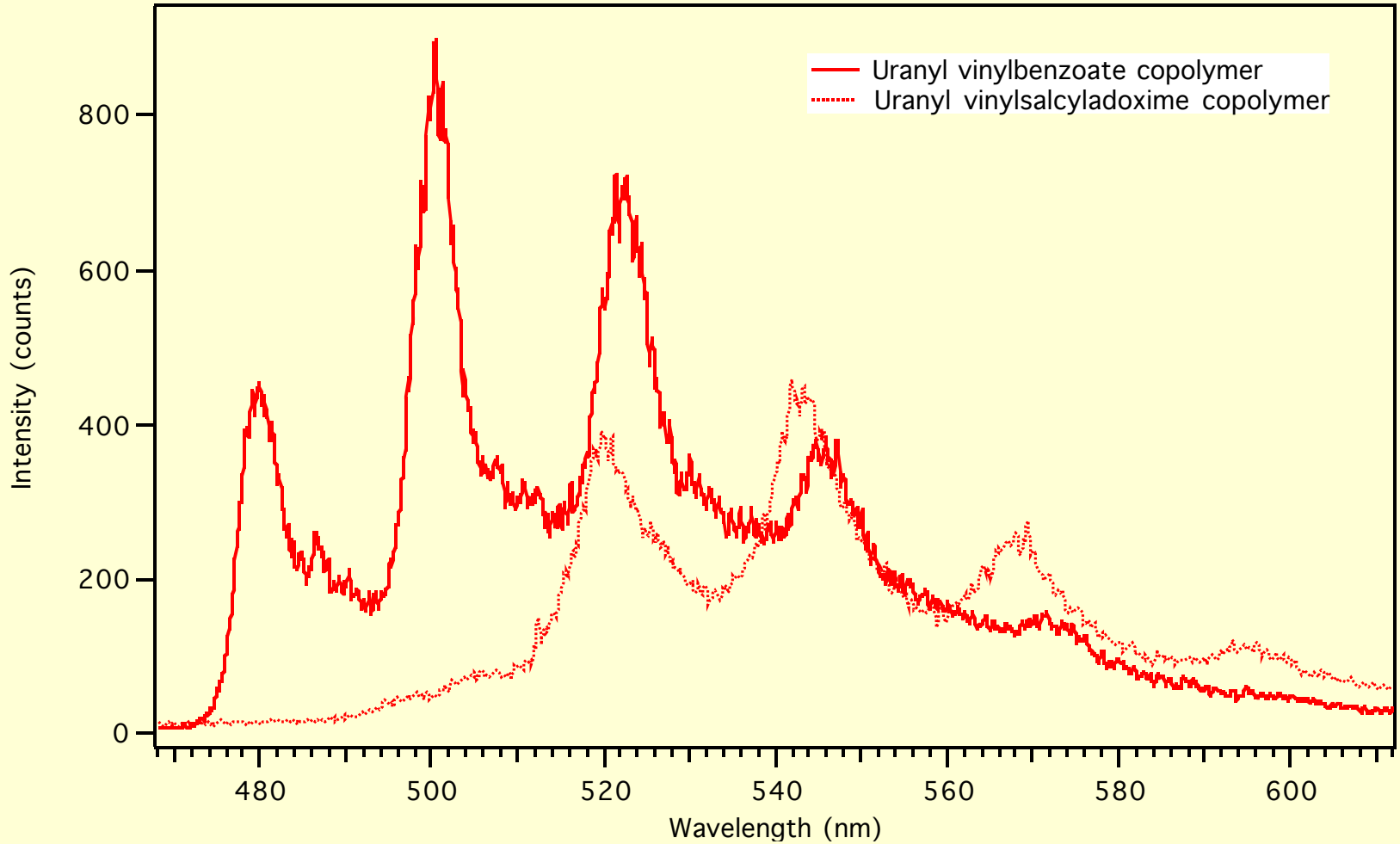
Uranyl Templated Electrode Performance



Room Temperature Luminescence of Benzoate Monomers and the Copolymer

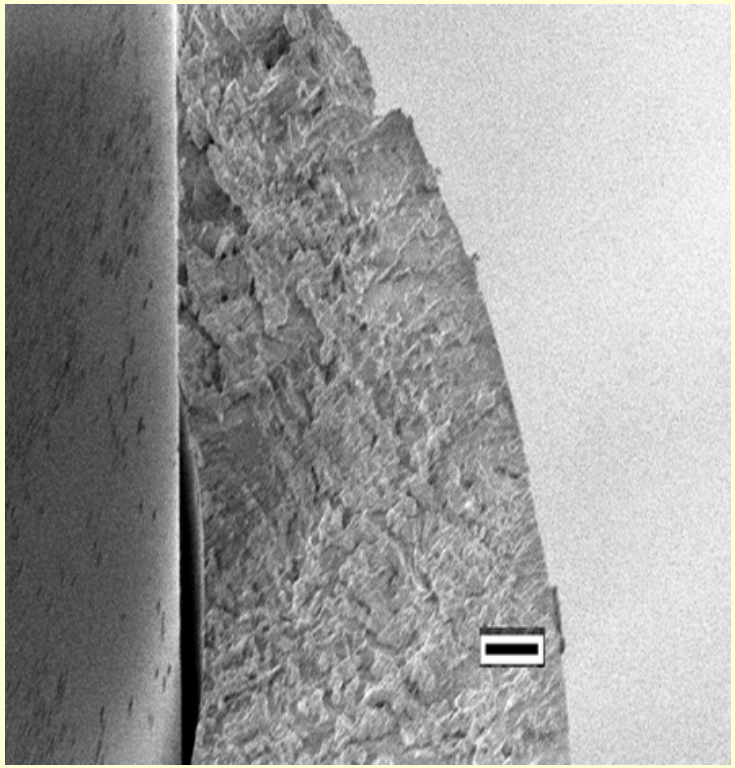


Low Temperature Luminescence Spectra of Uranyl Containing Polymers



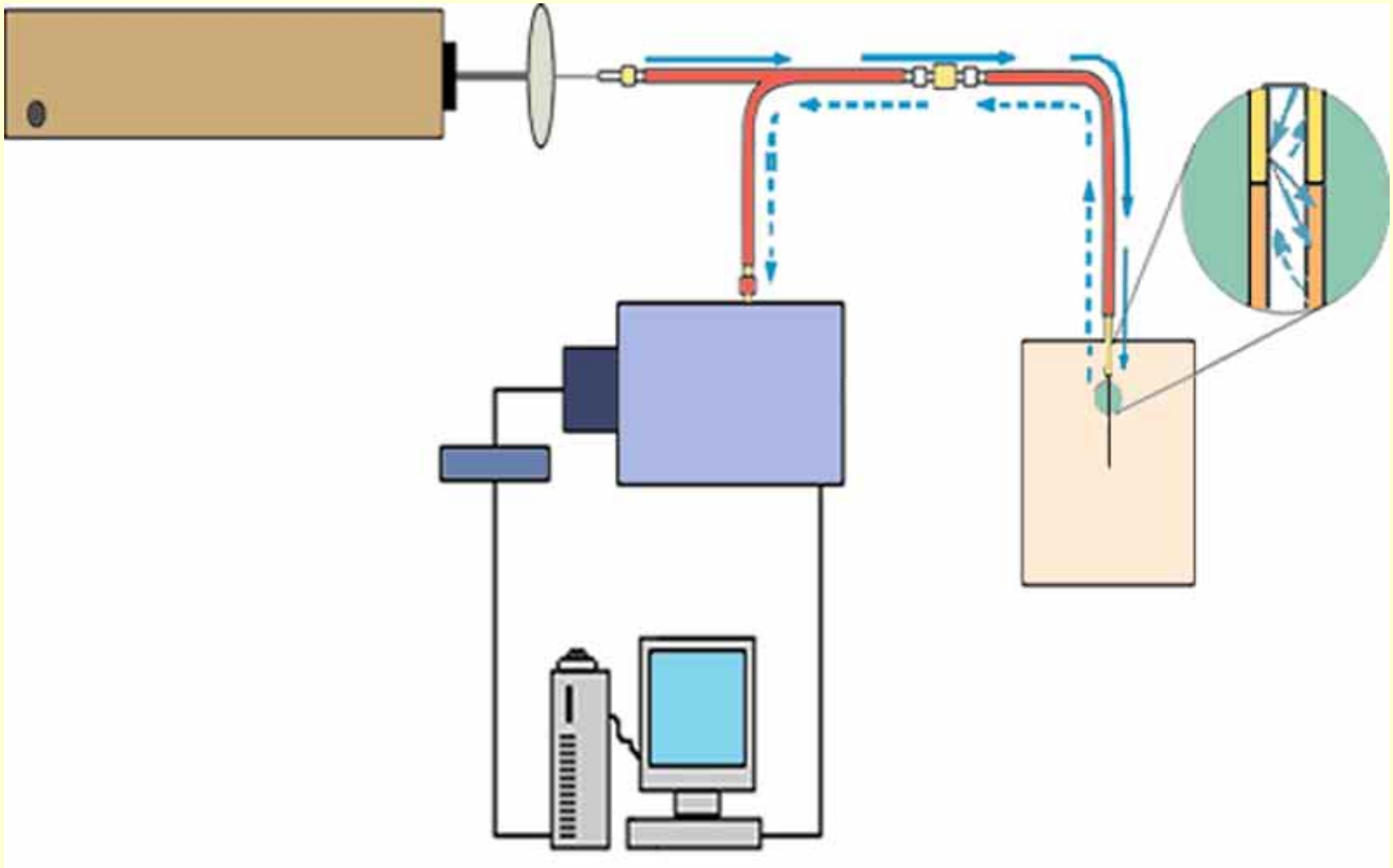
SEM Image of the Polymer Coated Optical Fiber

The polymer coated optical fiber at 60X.



The polymer coated fiber at 100X.

Optical Sensor Support



Conclusions

(1) Using the molecular imprinting technique, polymers which exhibit enhanced selectivity for UO_2^{2+} have been synthesized.

(2) Use of templated polymers as selective sequestering agents has been demonstrated.

(3) Use of templated polymers as the basis for uranyl ion selective electrodes has been demonstrated.

(4) A uranyl optrode is being constructed based on the sensitized luminescence of the imprinted polymer when uranyl is bound.