Removal of Heavy-Metal Pollutants from Groundwater Using a Reverse-Osmosis/Coupled-Transport Hybrid System

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Two membrane processes—reverse osmosis (RO) and coupled transport (CT)—are useful in removing heavy metals from aqueous solutions and producing purified water. Each process has advantages. RO produces clean water reliably and relatively inexpensively. However, the pollutants are removed nonselectively and cannot be appreciably concentrated. CT removes pollutants selectively and can concentrate them by several orders of magnitude, but CT suffers from limited reliability and performs poorly at low pollutant concentrations. By combining these two unit processes in a hybrid process, it is possible to capitalize on the advantages of each process and to minimize their disadvantages.

The RO/CT hybrid process we are developing removes more than 95% of the uranium and chromium in a contaminated groundwater stream—reducing concentrations of each pollutant to less than 100 ppb. These pollutants are simultaneously recovered as a concentrate at metal-ion concentrations greater than 1 wt% in relatively pure form. The hybrid process promises to be reliable and to reduce treatment costs below that for costs if either CT or RO were used alone. Even more importantly, the high selectivity of the hybrid process minimizes the volume of waste requiring disposal.

Figure 1 shows the patented RO/CT hybrid system we have designed for groundwater remediation. The system shown concentrates heavy metals in the groundwater 40-fold and reduces their concentration in the groundwater a factor of 10. This requires 1) an RO membrane with a heavy-metal rejection of about 98%, and 2) any necessary pretreatment such that the feed stream does not foul the membrane at this level of concentration. Bend Research RO membrane modules are particularly well-suited to this application due to their fouling-resistant design.

Figure 2 shows the hollow-fiber CT module to be utilized in the hybrid system. Concentrated groundwater enters the interior of the microporous hollow-fiber membranes on one end of the module. As the solution passes down the fiber length, chromium or uranium is extracted from the solution, depending on the type of organic ion-complexing agent contained in the walls of the hollow-fiber membranes. In the case of coupled transport of chromium (see Figure 3), a water-insoluble organic amine (NR_3) complexes chromium ($Cr_2O_2^{=}$) on one side of the membrane (at relatively low pH) and releases chromium to the strip solution (at relatively high pH) on the opposite side of the membrane.

Unlike conventional CT fibers (e.g., Accurel fibers), Bend Research CT fibers are asymmetric (see the table in Figure 2). This asymmetry simultaneously yields high metal-ion transport rates (fluxes) and improves the retention of ion-complexing agent by the fibers.

We plan to field-test the RO/CT hybrid system shown in Figure 1 within the next 1 to 2 years. This type of RO/CT hybrid system should be applicable to other similar waste-treatment problems, and other hybrid systems, such as RO/pervaporation or RO/carbon absorption systems, should have advantages similar to those offered by the RO/CT system.

(a) Bend Research, Inc., Bend, Oregon

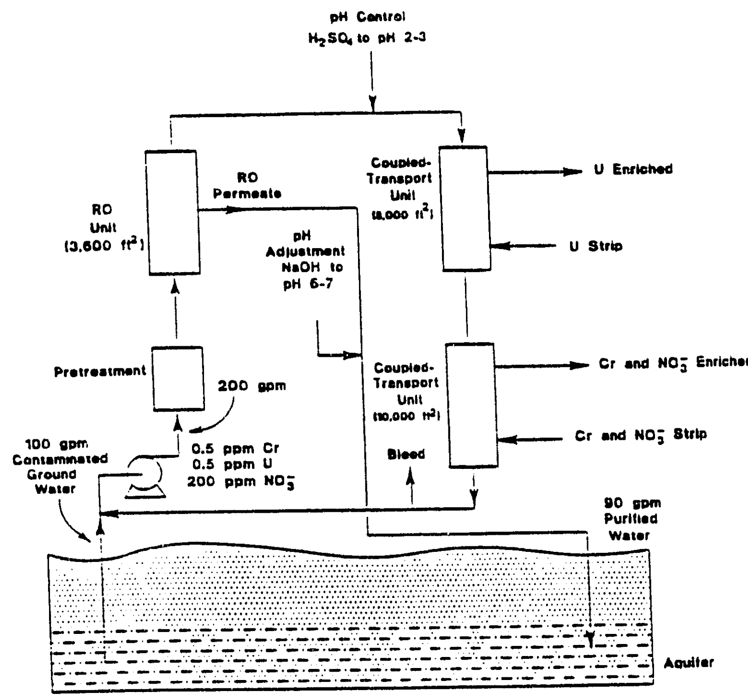
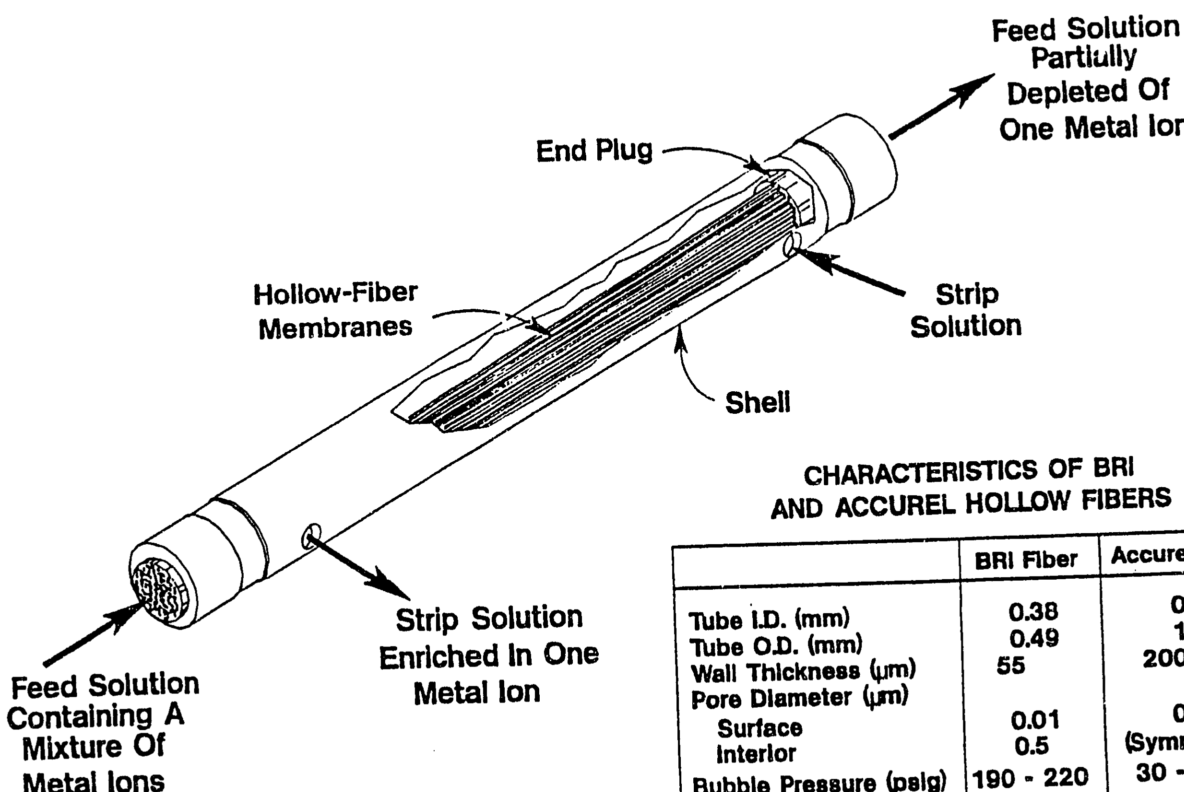


Figure 1. RO/CT Hybrid System for Groundwater Remediation



CHARACTERISTICS OF BRI AND ACCUREL HOLLOW FIBERS

	BRI Fiber	Accurel Fiber
Tube I.D. (mm)	0.38	0.6
Tube O.D. (mm)	0.49	1.0
Wall Thickness (μm)	55	200
Pore Diameter (μm)		
Surface	0.01	0.1
Interior	0.5	(Symmetric)
Bubble Pressure (psig)	190 - 220	30 - 40

Figure 2. CT Hollow-Fiber Modules

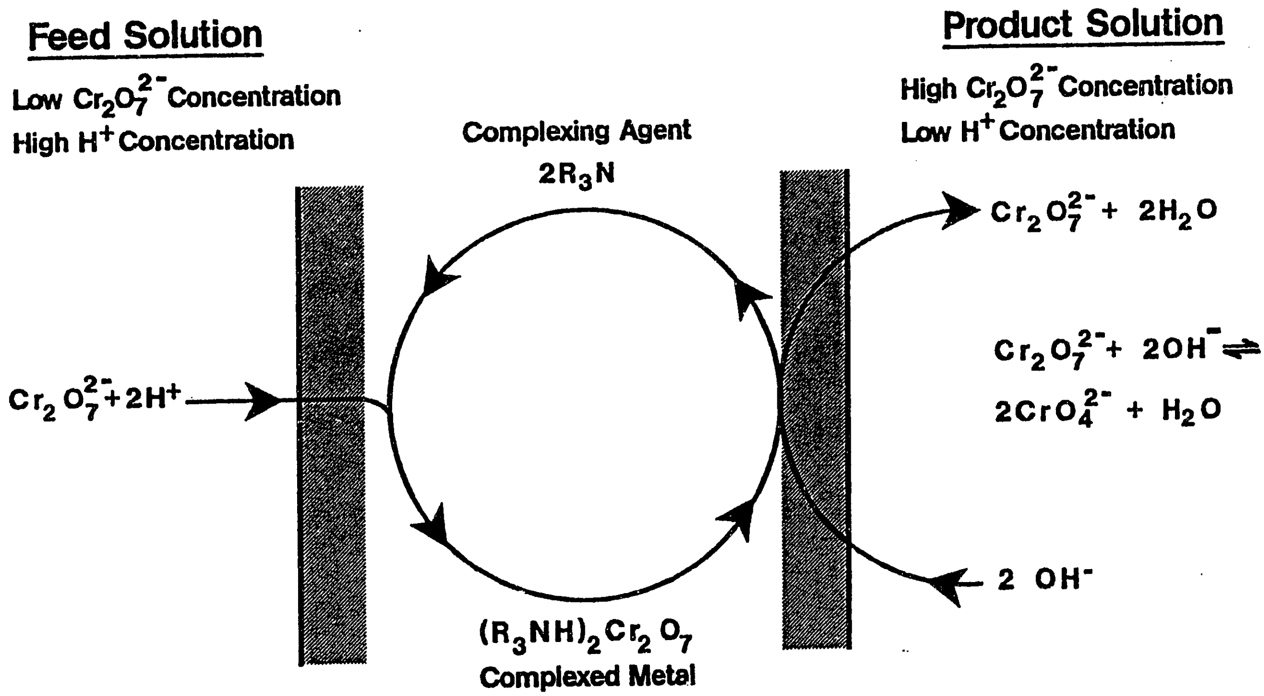
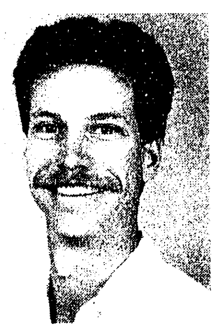


Figure 3. Chemistry of Chromium CT



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