



Progress in Recycling of Retired Cadmium-Telluride Photovoltaic Modules

Postdoctoral: Wenming Wang

Supervisor: Vasilis Fthenakis

Department of Environmental Sciences

Brookhaven National Laboratory

EENS Cross-Talk Program

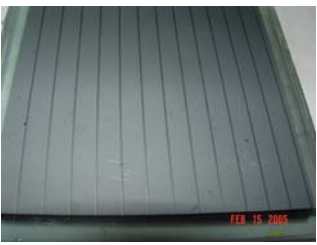
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Recycling Retired Photovoltaic Modules to Valuable Products, Where Are We Standing?

Energy Efficiency and Renewable Energy

Used PV Modules



Processing Facility
(Ion Exchange Separation)



PV Module Fragments



Tellurium Product



Cadmium Metal



Clean Glass





CdTe Module Fragments(Crushed with Hammer Mill)

Components of the fragments

- Glass: 97%
- EVA flakes: 3%
- Cd: ~0.06%
- Te: ~0.075%
- Cu





Ion Exchange Separation Device

Influent solution:

Te~1000 ppm

Cd~900 ppm

Cu~150 ppm

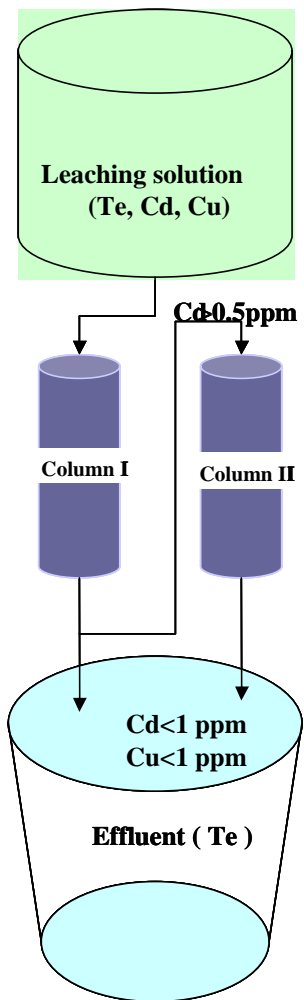
H₂SO₄: 0.5 M (pH: ~0.53)



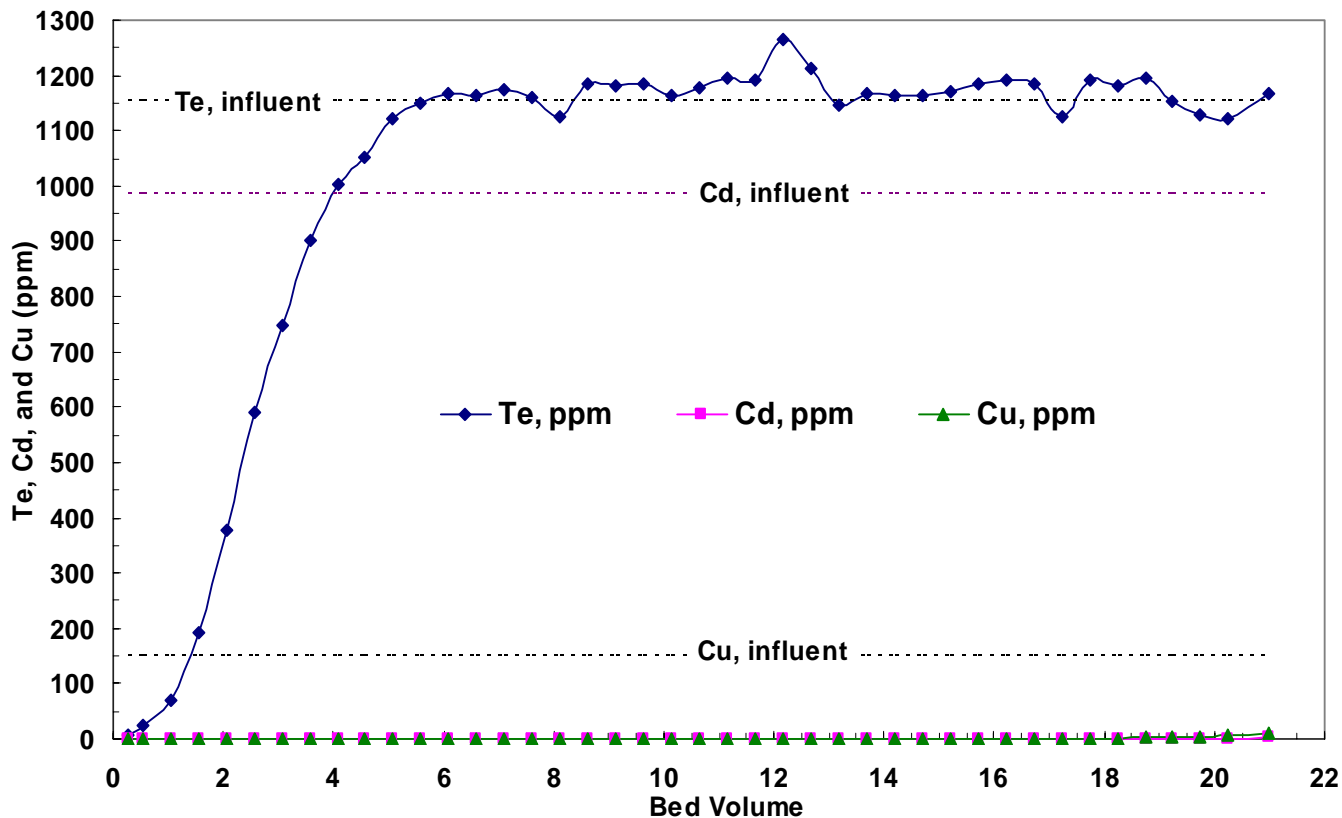
US Patent Pending: Assigned Series Number- 60/686,911



Ion Exchange Separation with Two Columns in Series



Influent flowrate: 7.5 BV/hr.



(Concentration of Influent: Te-1155 ppm, Cd-989 ppm, Cu-154 ppm. CdTe powder used as raw material. Resin:Amberlyst 15-WET. Two columns in series)

Cd and Cu Removal: 99.95-99.99%
Cd and Cu in Effluent:<1ppm

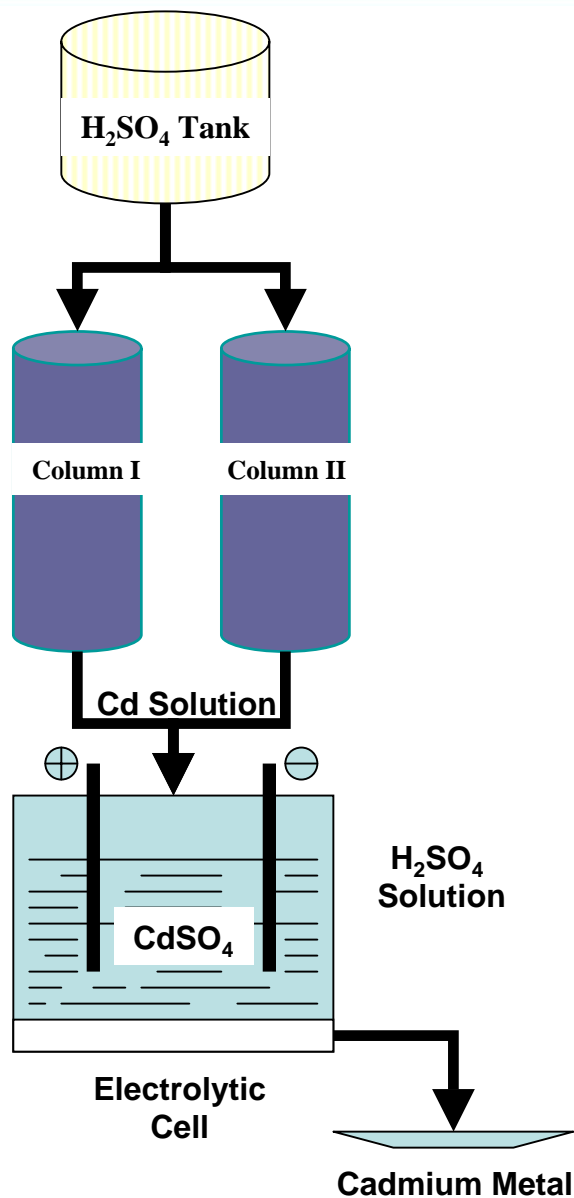


Tellurium Products

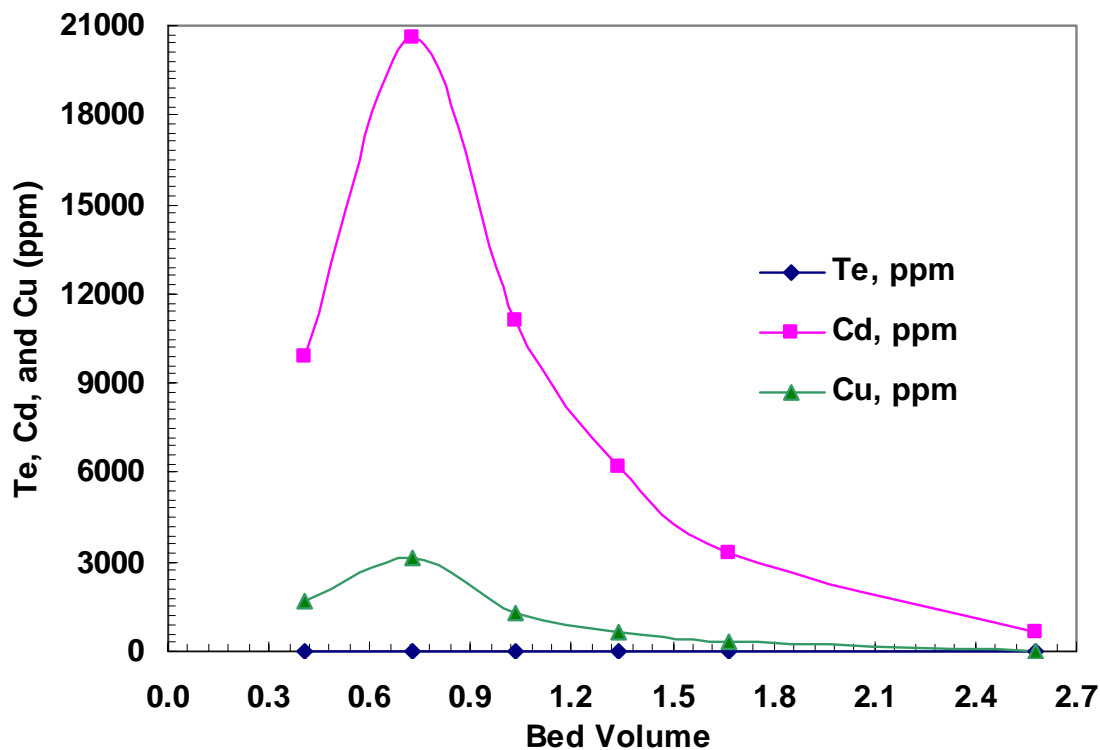


Container

Tellurium precipitates



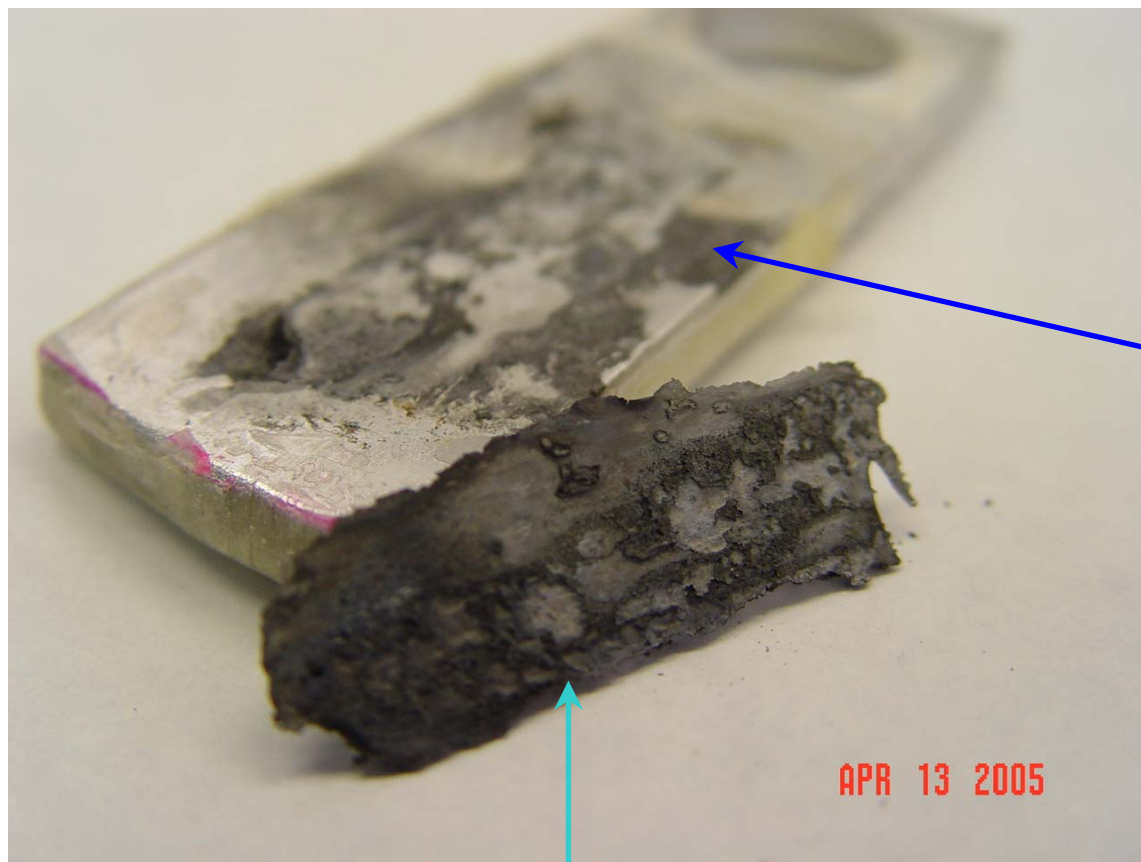
Elution of Ion Exchange Resin



Elution curve (Resin: Dowex 50, Eluted with 5.0 M H₂SO₄)



Cadmium Product



Cathode electrode

Cadmium metal plate deposited



Clean Glass (Pass TCLP)





Our Achievements

–US Patent Pending: Assigned Series Number- 60/686,911

–Wang, W. and Fthenakis, V.M., Feasibility of Recycling of Cadmium-Telluride Photovoltaics, Presented at 134th TMS Annual Meeting & Exhibition (February 13–17, 2005, San Diego, California) *The Minerals, Metals & Materials Society (TMS) Extraction & Processing Division (EPD) Congress 2005, pp. 1053-1064*

–Wang, W. and Fthenakis, V.M., Kinetics Study on Separation of Cadmium from Tellurium in Acidic Solution Media Using Cation Exchange Resin, *Journal of Hazardous Materials, in press*

–Fthenakis, V.M. and Wang, W., Advances in the Recycling of Cadmium Telluride Photovoltaic Modules, submitted to *Progress in Photovoltaics*