Technology Summary: Spent Grain Adsorbent Material for Heavy Metals Removal from Wastewater

Opportunity Statement

Water pollution due to toxic heavy metals is a major cause of concern in many countries. Unlike other pollutants, heavy metals are difficult to degrade and can accumulate in the environment and food chain, creating significant health risks to the public. High levels of exposure to heavy metals have been known to cause cancer, organ damage, joint diseases, and in extreme cases, death.

Enactment of water legislations worldwide has created a growing demand for water treatment technologies, especially in the emerging economies. The market for water treatment products in India is estimated to be US$1 billion and China has announced plans to invest US$50 billion in wastewater treatment under its 11th Five Year Plan. There is a huge potential market for technologies that can offer a cost-effective solution to heavy metals removal.

Current technologies for treating heavy metals include the following:

1. **Chemical Precipitation**

   Chemical precipitation involves the transformation of dissolved contaminants into insoluble solids, thereby facilitating the contaminants' subsequent removal from the wastewater. Heavy metals are usually precipitated by adding coagulants like lime to the wastewater. It is a well-established process with readily available equipment and chemicals. A major disadvantage of this process is that large volumes of sludge are usually generated, which leads to additional waste disposal costs.

2. **Ion Exchange**

   Ion exchange is a reversible chemical reaction where the metal ion from the wastewater is exchanged for a similarly charged ion attached to an immobile solid particle. These solid ion exchange particles are either zeolites or organic resins. One shortcoming of this process is that the cost of the adhesive may be prohibitive to smaller companies, especially in developing countries.

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3. **Adsorption**

Adsorption involves the addition of an adsorbent material to the wastewater that, by chemical and physical processes, causes the contaminants to attach to the material for later disposal. Recent research has shown that it is possible to use agricultural byproducts like spent grain as an absorbent for heavy metal removal. The sorption properties of these materials are due to the presence of functional groups such as hydroxyl, carboxyl and amine groups, which have a high affinity for metal ions. This technology has great potential as many agricultural byproducts are easily available and can be obtained at low cost. However, the adsorption capacity of agricultural byproducts is generally low compared to ion exchange resins**.**

Problem

Conventional technologies are not able to provide low-cost and effective removal of heavy metals from wastewater. Adsorption processes using agricultural byproducts can potentially provide a low-cost solution, but the adsorption capacity needs to be improved.

Therefore, there is a need for a technology that provides an adsorption process using agricultural byproducts with high adsorption capacity.

360ip Partner's Solution

The 360ip Partner's invention relates to the production and use of esterified spent grain (ESG) as an adsorption material for the removal of heavy metals in wastewater. Spent grain is a common byproduct in the beer industry, and is usually not fully usable as animal feed, potentially creating a costly disposal problem.

The novel process of creating the ESG involves the use of citric acid as esterifying agent, NaH2PO-2•H2O as catalyst and N, N-dimethylformamide (DMF) as reaction medium to create an ESG with high adsorption capacity for heavy metal ions. The use of DMF also serves as a swelling agent that can enhance the reaction activity and shorten the process time.

The key advantages associated with this technology are as follows:

- Low-cost process using easily available spent grain material
- Short processing time for production of the ESG
- High adsorption capacity, superior to ion-exchange resin (see Annex A)
- ESG can be desorbed and reused at least three times (see Annex B)

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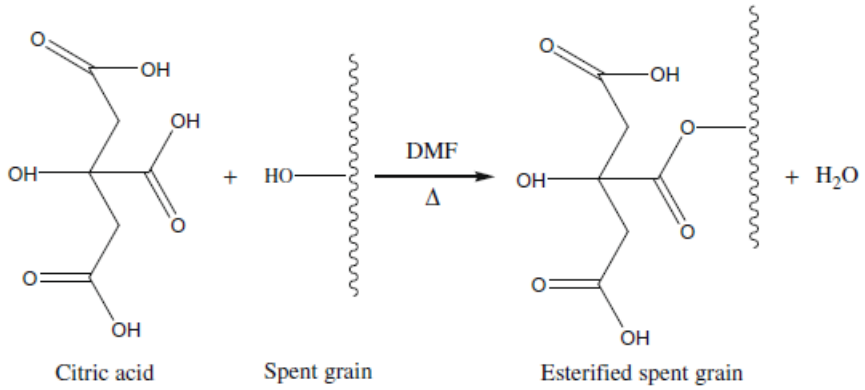

Patents

360ip's Partner has filed one patent application on this invention and plans to seek protection in multiple jurisdictions.

Summary

360ip's Partner has developed a process for producing a cost-effective adsorption material from spent grain for removal of heavy metals from wastewater.

360ip is seeking interested parties for the licensing, further development and commercialization of this technology-based solution.

For additional information, contact:
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Annex A (Adsorption capacity of ESG)

1. **Adsorption capacity of ESG compared with ion- exchange resins**

Adsorption capacity of ESG and ion exchange resins (mg/g)

	Pb	Cu	Zn	Cd
ESG	**393.70**	**129.03**	**269.54**	**471.70**
Duolite GT-73	122.25	61.60	55.59	105.66
Amberlite IRC-718	290.08	127.00	156.96	258.32
Amberlite 200	352.24	88.90	85.60	224.80
Lewatit TP 207	198.90	85.09	89.60	49.46

*Data on ion-exchange resin taken from **Ref [2]**

Experimental data shows that ESG prepared using the partner's technology can provide adsorption capacity as high as **393.70mg/g, 129.03mg/g, 269.54mg/g, 471.80mg/g** for Pb, Cu, Zn and Cd respectively. This compares very favorably to existing ion-exchange resins in the market.

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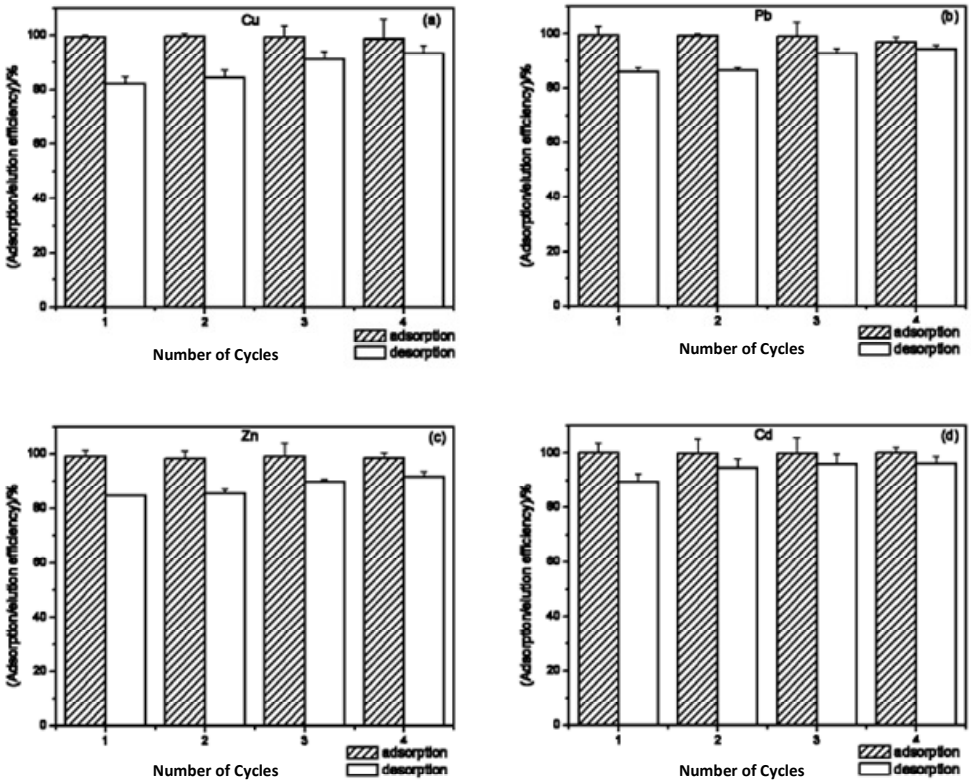
Annex B (Reuse of ESG after desorption)



Experimental data shows that it is feasible to reuse the ESG at least three times.