A Method for Maximizing Multicomponent Adsorption of the Solutes from an Aqueous Stream Discharge

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Problem Statement & Unmet Need

- Aqueous stream **discharges** contain various **compounds** that may be removed before recycling the water using **multicomponent adsorption**; wherein, the affinities of **different solutes** in the multicomponent mixture towards the adsorbent may be different from the affinities when these **individual solutes** are present alone in the solution.
- When a large number of components **(>3)** is involved, the multicomponent adsorption experiments and analytical methods may become **tedious**, **expensive** and **time consuming**.
- Multicomponent adsorption isotherms are often predicted from **single component** isotherms, **formulation** of multicomponent isotherms through the development of **Artificial Neural Network (ANN) models**, empirical model development using **design of experiments (DOE),** etc. However, we realized that factoring in the effects of process conditions as well as mixture compositions on adsorbent capacity and interpreting their individual and joint influence is not straightforward.

Thus, the present patent herein discloses a **method** that addresses the above issues.

Technology Category/ Market

Chemical Engineering- Manufacturing, Engineering

Industry- Advanced Materials, Catalysts, Food & Drugs, Waste Management & Water Treatment

Applications: Wastewater Treatment Plant (WWTP), Decentralized Treatment Plant of a housing complex, Optimum Adsorption and Water Recycle.

Market– The global multicomponent adsorbents market size value was **USD 4.10B** in **2021,** expected to make revenue with **CAGR of 5.7%** during the forecast period.

Technology

- The invention herein discloses a **method** to maximize multicomponent adsorption of the solutes from an aqueous stream discharge by **increasing** the total solute loading **(qTotal)** of the adsorbent to the maximum loading capacity **(global maximum)**.

The experimental and statistical validation of **Mixture Process Variable (MPV) design** determines the main and interaction effects of mixture compositions, pH, adsorbent dose & adsorbent type on the **qTotal** for arriving at the global optimum.

Further, arrive at a ***loci*** of maximum adsorbent loading ***en route*** to the globally optimum **qTotal** from any initial composition and process conditions using enhanced ridge analysis and **numerical constrained optimization techniques.**

Where, **qTotal** = total solute mass loading on the adsorbent, also termed as total adsorption capacity and total adsorbent loading.

Global maximum: is the maximum possible total solute loading in the adsorbent within the bounds of the experimental variables chosen.

Method:

A method comprises of following steps:

Determining the mixture and the process variables of the adsorption wherein the mixture variable is feed concentration of one of the different solutes present in the aqueous stream and the process variable is one of pH, adsorbent dose and type of the adsorbent;

↓

Determining the main and interaction effects of mixture variables, pH, adsorbent dose and adsorbent type on qTotal using a mixture process variable design;

↓

Arriving at a global maximum for qTotal from specified mixture variables, using circular constraints and simultaneously optimizing the values of both the said mixture & said process variables, and identifying the path of steepest ascent using enhanced ridge analysis;

↓

Validation of qTotal arrived from the mixture process variable design; wherein, the maximum total solute loading (qTotal) of the adsorbent is a function of both mixture & process variables.

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- Wherein, the **pH** is from **3 to 10**, **dose of adsorbent** is from **0.6 to 1.2 g/L**, number of various **adsorbent** in the mixture is **3** & number of **solutes** in **MPV** design is **3**.
- The MPV design using optimization with constraints in the variables of **both the mixture & process** are optimized separately in two loops, wherein mixture variables are optimized in the first loop & their updated values in turn are **fed back** to the process variables optimization in the second loop.
- The constraints of the mixture variable is a function of the feed concentration when **tracking the path** towards global optimum during the said enhanced ridge analysis.
- The **feed concentration** of individual mixture variable is between **0 and 700 mg/L**
- The **total feed concentration** of the mixture variable is **specified value of 700 mg/L**.
- The constraints of the process variable is fixed as per the **lower** and the **upper bounds** of the **specified process variables**.
- The (qTotal) of the experimental and the **predicted** value is a difference of **±10%.**

Image

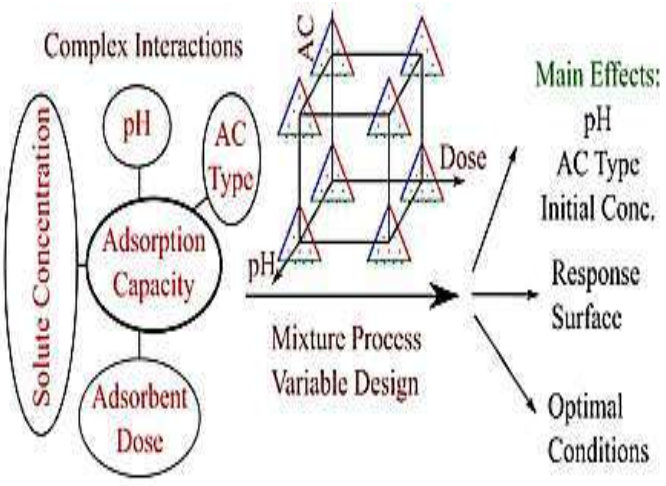

Figure 1 represents the different mixture and process variables and identification of their effects and interaction through a mixture process variable design.

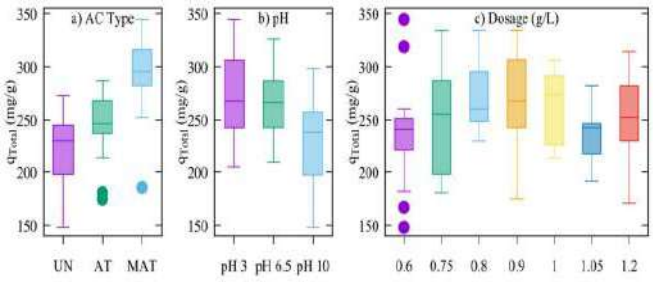

Figure 2 represents the experimental responses of total solute loading (qTotal mg/g) for each process variable revealing the uniqueness of AC type and pH.

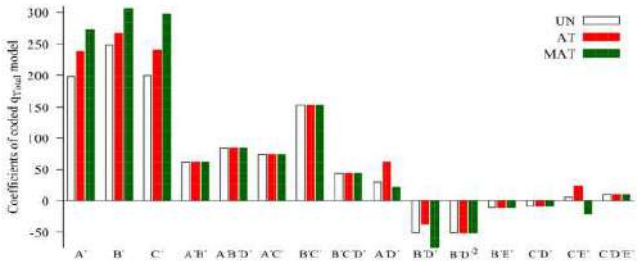

Figure 3 compares the coefficients of the coded qTotal model for the three carbons UN, AT and MAT and highlights the interaction effects

Intellectual Property

IDF Ref: 1907
IN Patent No. 412625 (**Granted**)

Key Features / Value Proposition

❖ ***Industrial Perspective:***

- Economical process for wastewater treatment
- Efficient Wastewater and solid waste management.
- Water Recycling

❖ ***Technical Perspective:***

- Enables maximum utilization of carbon's adsorption capacity

TRL (Technology Readiness Level)

TRL-4 Components validation in Laboratory

Research Lab

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