VIETNAM NATIONAL UNIVERSITY - HCMC
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY

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DISSERTATION INFORMATION

Title:	***The study on preparation of new materials from rice husk ash for simultaneously adsorbing of organic matter, nitrate, phosphate in wastewater***
Major:	**Environmental Engineering** Major code: **62520320**
PhD candidate:	**Phan Phuoc Toan**
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Major Contributions of This Dissertation:

This dissertation has focused on utilizing waste rice husk ash from local incinerators (mainly silicon oxide and carbon) as raw materials to prepare a new material capable of simultaneously absorbing three components including organic matter, nitrate, and phosphate in wastewater under laboratory conditions.

Firstly, the dissertation has successfully synthesized a novel material from rice husk ash (TRI-ARHA) by grafting triamine groups onto the surface of rice husk ash carrier after being activated by corrosion method with hydrofluoric acid (HF) with a simple proposed process, requiring neither surfactants nor high temperatures for activation. The results of optimization by design of experiment determined that the concentration of HF acid solution ~ 4.855% and the ratio of triamine silane/ARHA ~ 3,123 mL/g were the optimal conditions for the synthesis of the material. The analysis results of FTIR, XRD, TGA, BET, SEM, EDX, and SEM-mapping clearly showed the basic characteristics and chemical composition of TRI-ARHA material with specific surface area of ~ 402 m^2/g and amine content of ~ 23%. The elements of O (36.4%), C (33.6%), Si (22.6%), and N (7.4%) are well dispersed on the surface synthesized material.

Next, studying the adsorption properties for organic matter (methyl orange), nitrate and phosphate has shown that TRI-ARHA material has many outstanding advantages such as high adsorption capacity (Q_{max} ~ 172 mgMO/g, 132 mgNO_3^--N/g and 84.4 mgPO_4^{3-}-P/g), fast adsorption equilibrium (10-20 minutes), favorable pH environment (pH 5-7) and good durability. Compared with others of adsorbent materials, the TRI-ARHA material has a good capacity to simultaneously adsorb all three components of organic matter, nitrate and phosphate by a mechanism of adsorption - ion exchange which combined by the outstanding

characteristics of the ARHA support and the strong activity of triamine groups grafted on the surface material. The special discovery is obtained that is the enhancement of the adsorption capacity of nitrate and phosphate ions when simultaneously adsorbing with methyl orange (an organic compound containing amine and azo functional groups) through a new adsorption mechanism that has may occur on the surface of the material.

One of the highlights of the dissertation is the combination of experiments and computational chemistry processed by Gaussian 16 software (with utilizing density function theory (DFT) with B3LYP/6-32G*) to study and explain a special adsorption mechanism of this new material. The results have discovered and proposed a new mechanism for the adsorption process, named "conjugated adsorption mechanism" and this mechanism can be defined as an adsorption process in which the binding of components released from ion exchange (e.g., Cl^- and Na^+/H^+) further activates and forms new adsorption sites in combination with existing ones, resulting in further enhancement of the multi-component adsorption capacity of the material. This new mechanism can be extended to account for other adsorbent combinatorial objects similar to chromogenic compounds/organic amines and other anions.

Finally, when testing on livestock wastewater, TRI-ARHA has shown superior capacity to adsorb organic matter, nitrate and phosphate compared to two common commercial adsorbents, activated carbon and ion exchange resin, which simultaneously reduce three parameters of BOD_5, TN and TP to meet the current discharge standards, thereby serving as a basis for proposing improvements to the actual wastewater treatment process to enhance the efficiency of pollutant treatment before being released into the environment.

In summary, this dissertation has effectively utilized the natural source of carbon and silica in the porous structure of rice husk ash to create a support for the grafting reaction with amine functional groups, preparing a new material with good adsorption capacity for many pollutant components on different adsorption sites. This is evaluated as a new contribution and rarely observed in previous studies on adsorbents, contributing to competition with common commercial adsorbents, such as activated carbon and ion exchange resin (which are now mainly imported from China). In addition, a special new contribution of this dissertation is the discovery and proposal of a new mechanism for the adsorption process, which is "conjugated adsorption mechanism". This new material has shown potential applications in water and wastewater treatment processes with superior features compared to other materials available on the market, contributing to reducing environmental pollution in many fields and avoid wasting resources.

Advisors **Ph.D. candidate**

Assoc. Prof. Dr. Nguyen Trung Thanh **Assoc. Prof. Dr. Nguyen Nhat Huy** **Phan Phuoc Toan**