Consiglio Nazionale delle Ricerche
Istituto di Scienze e Tecnologie per l'Energia e la Mobilità Sostenibili
STEMS

July 17, 2021

**Review**

**of the Foreign Scientific Supervisor to dissertation work by Zhumagaliyeva Assem Nurbergenovna, entitled: "Production and testing of carbonized rice husk-based nanocomposites for capturing of carbon dioxide" provided for the degree of Doctor of Philosophy in specialty 6D074000 – Nanomaterials and nanotechnologies**

I am submitting my feedback and judgement on the dissertation work of Zhumagaliyeva Assem Nurbergenovna entitled: "Production and testing of carbonized rice husk-based nanocomposites for capturing of carbon dioxide", presented for the PhD degree in the specialty 6D074000 - Nanomaterials and Nanotechnology, as her Foreign Scientific Supervisor.

Part of the scientific work of her PhD program has been performed during the internship of Ms. Zhumagaliyeva Assem Nurbergenovna in Naples (Italy) in my laboratory at the Institute for Research on Combustion (IRC) of the National Research Council (CNR) (from 1st October 2020, Institute of Sciences and Technologies for Sustainable Energy and Mobility, STEMS).

The main issue of her PhD work concerns the synthesis of carbon-based nanocomposites modified at the surface by iron-oxide nanoparticles coating. The nanocomposites were tested for $CO_2$ adsorption in typical post-combustion flue-gas conditions ($CO_2$ 1–15% vol., atmospheric pressure) where the $CO_2$ uptake capacity is influenced primarily by material functionality effects rather than material pore metrics. For this reason, much attention has been paid on the development and on a deep characterization study of new materials whose physical and chemical properties can be tuned at the molecular level by acting on the porosity and/or the coverage with a $CO_2$ active phase as magnetite ($Fe_3O_4$). The PhD work was accomplished crossing one of the main current issues related to the utilization and valorization of end-of-life materials as agricultural wastes. In this framework, rice husk (RH) has been used as the starting material for the development of $CO_2$ sorbents, because of its wide availability as waste material in all rice producing countries (among them, Kazakhstan).

The dissertation consists in 3 Chapters. In Chapter 1 an intensive literature survey and a systematic introduction have been made clarifying the objective and scope of her thesis in the framework of carbon capture and storage (CCS) strategies. In Chapter 2 she introduces the methods adopted to obtain, characterize and probe as $CO_2$ sorbent, two classes of RH-based sorbents: i) carbonized RH (cRH), cRH treated with alkali (cRH-$NH_4OH$ and cRH-NaOH) and ii) cRH covered with magnetite particles (FM) and magnetite nanoparticles (nFM). A class of sorbent was also produced combining nFM with a reference nanostructured carbon black (CB).
The Chapter 3 presents the sorbent characterization results: a wide array of analytical techniques is applied and the results crossed and discussed for all sorbents.

The performed work successfully achieved some relevant results:

- The valorization of a wide available agricultural waste (RH) through chemical treatments has been demonstrated as a feasible possibility to produce nanostructured cRH/iron-oxides (magnetite and nanomagnetite) composites also active for $CO_2$ sorption;

- It was assessed that the combination of cRH and nanostructured iron oxides do not provide obvious benefits from a synergistic cooperation of the two phases (carbon phase and active iron oxides phase);
- It was assessed that the $CO_2$ capture sorption mechanism of cRH/iron-oxides is intermediate between a pure chemisorption and a pure physisorption interaction;
- A high-performance $CO_2$ sorbent (33.59 mg/g) by a simple alkaline treatment with hot $NH_4OH$ solution was produced;
- It was assessed that the removal of ashes (mainly $SiO_2$) is beneficial in incrementing of 35% the $CO_2$ capture capacity compared to untreated cRH.

Overall these results encourage a profitably use cRH and treated cRH as low-cost biomass-derived materials for $CO_2$ capture in realistic contexts.

The choice of research topic, the related methods, the huge experimental effort carried out and the results within accomplished are appropriate for a high-level PhD thesis. In my opinion, the dissertation work was carried out in a good accordance with the research program of the Ministry of Education and Science of the Republic of Kazakhstan.

Besides the dissertation, I also had the opportunity to interact with Assem during her work in Naples, and I appreciated her determination, hard-working and skills.

Considering the performed work and the way she faced it, the scientific novelty and the significance of the achieved results, I conclude that Ms. Zhumagaliyeva Assem Nurbergenovna's dissertation fully complies with the international scientific requirements and I recommend her to be awarded with the PhD degree.

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