

УДК 54.064

NANOCOMPOSITE MATERIAL LIKE ADVANCED SORBENT MATERIALS FOR CARBON DIOXIDE CAPTURE

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Abstract

In this work carbonized rice husk was used as carbon-based solid matrix in the preparation of composite materials modified with Fe₃O₄ particles. Aim of this study is to exploit the advantages and shortcomings of using a real biomass as starting material for the preparation of sorbents for CO₂ capture applications. Sorption capacity of the obtained composite materials was tested on fixed-bed microreactor.

Keywords: carbon dioxide capture, sorbent, rice husk, ferric oxide, fixed-bed microreactor.

Introduction

International scientists deserves greater emphasis to the problem of greenhouse gases emissions into the atmosphere. Specific importance was given to the development of CO₂ capture and storage strategies. To this aim, CO₂ capture and storage programm (CCS) is still considered the main strategy for achieving CO₂ emission reduction targets. A lot of materials have been explored as CO₂ sorbent, including amine-impregnated solids, carbon-based and graphite/graphene-based materials, LDH-based sorbents, zeolite-based materials, clay-based adsorbents, alkali metal carbonate-based adsorbents, MOF-based sorbents, silica-based sorbents, polymer-based adsorbents, immobilized ionic liquid-based adsorbents, MgO-based sorbents, CaO-based sorbents, alkali zirconate-based sorbents, alkali silicate-based sorbents etc. [1-11]. In this work testing composite material based on rice husk and ferric oxide/nanomagnetite.

Rice husk (RH) is an agricultural waste abundantly available in rice producing countries, obtained during the milling of paddy (22 wt.% of the weight of unmilled rice is received as husk). It presents a high ash content, which is 82 to 97% made by silica. RH being the outer shell of rice kernels protects the internal components from external attacks of insects and bacteria, but also RH need to get air and moisture for the growth of corn. Due to this peculiar function, rice in the process of natural evolution has created in its husk

characteristics shapes with nanoporous layers. These properties let us applying RH in different field of science: in biomedicine and environmental applications, Li-ion battery anodes, as fertilizer, as a mineral admixture in concrete, petroleum adsorption and etc. When RH is carbonized under controlled conditions its surface area and porosity increase making carbonized RH a good candidate for CCS approaches [12-16]. The carbonization of raw RH was performed in an auger furnace in the 500-800 °C temperature range for 3 hours like in previous work experimental obtaining carbonized rice husk (cRH) [17].

Experimental

Following the same approach with ferromagnetite (FM) reported in [17, 18] a set of five cRH/FM composites was produced by varying the amount of cRH from 0 to 100 wt.%. Starting from the procedure reported in [19] for the preparation of magnetite nanoparticles (nFM) in presence of a surfactant (TMAOH), a new approach was developed for the production of cRH/nFM composites by varying the amount of cRH from 0 to 100 wt.%. More information about the composites, procedure of obtaining and other stuff provided in Figure 1. By the way, we get 5 composites with different amount of magnetite and 5 composites with different amount of nanomagnetite (Fig. 2). Also obtained control samples of FM and nFM (without carbonized rice husk), two samples without ferric oxide cRH-NH₄OH and cRH-NaOH.

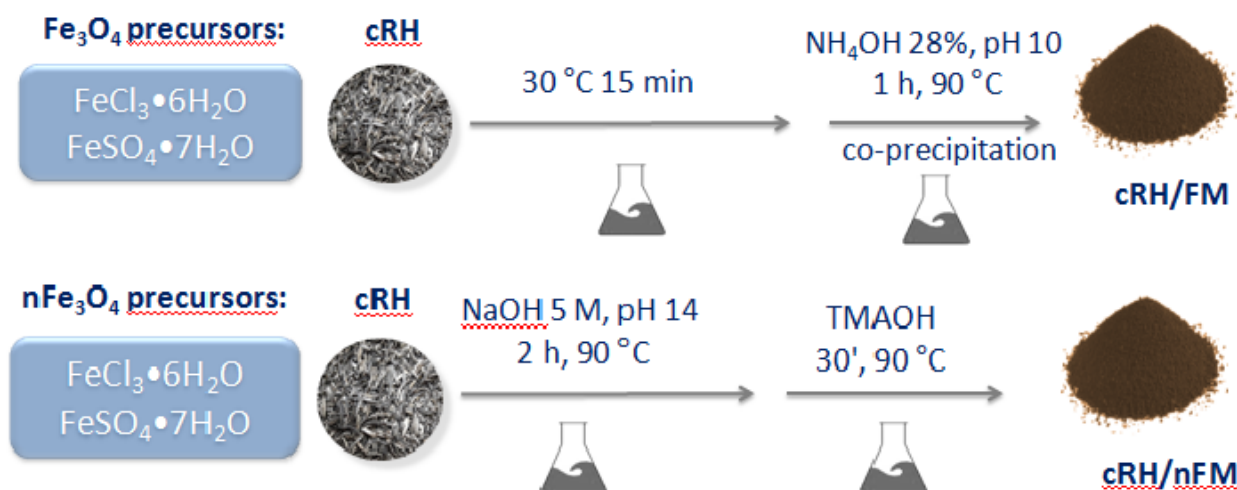


Figure 1. Schematic instructions for obtaining composites.

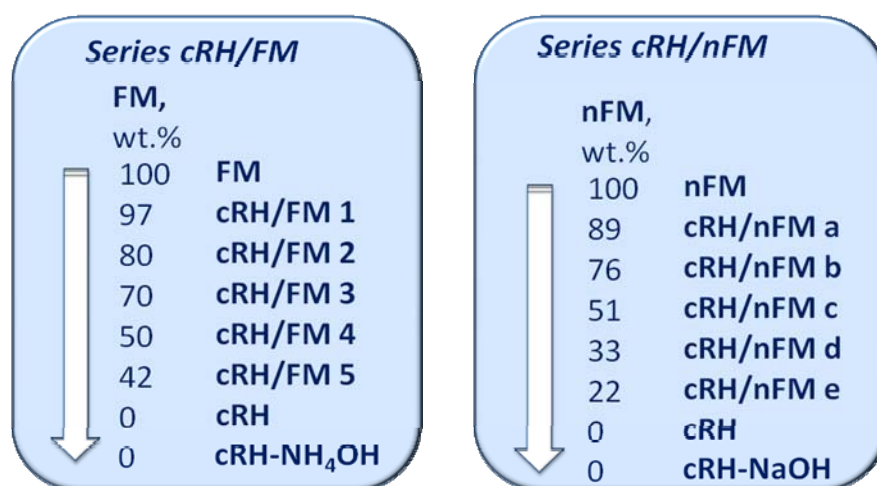


Figure 2. Two series of samples (simple and nano).

Elemental analysis. The differences in the compositions of the samples belonging to the two series can be explained by the effect of the synthetic conditions applied: the strong alkaline conditions generated by NaOH 5M allowed the SiO₂ dissolution on the contrary of NH₄OH (28%), thus in the series cRH/FM the content of inorganics is higher (Fig. 3).

Surface area (Fig. 4). The SiO₂ removal under strong basic conditions adopted during the synthesis of cRH/nFM samples allowed the production of sorbents with higher surface areas.

Results and discussion

Carbon dioxide sorption activity of cRH-NH₄OH and cRH-NaOH was assessed by tests in a fixed bed reactor with CO₂/N₂ gas mixture (15 Nl/h) at a fixed CO₂ concentration (3% vol), oper-

ating under atmospheric pressure. The CO₂ concentration in the inlet and outlet gas streams has been measured by online continuous ABB infrared gas analyzer. A laboratory scale fixed bed Pyrex microreactor (ID = 1 cm, length = 60 cm) operating under atmospheric pressure has been used for the preliminary evaluation of the CO₂ adsorption capacity of different samples. N₂ and CO₂ flowrates have been set by means of mass flow controllers (Bronkhorst), and subsequently mixed before entering the bed. The CO₂ concentration in the column effluent gas is continuously monitored as a function of time until the gas composition approaches the inlet gas composition value, until bed saturation is reached. The time taken by the gas mixture to flow from the fixed bed to the analyzer has been previously measured by flowing the gas mixture through the empty bed (about 50 s) [19, 20].

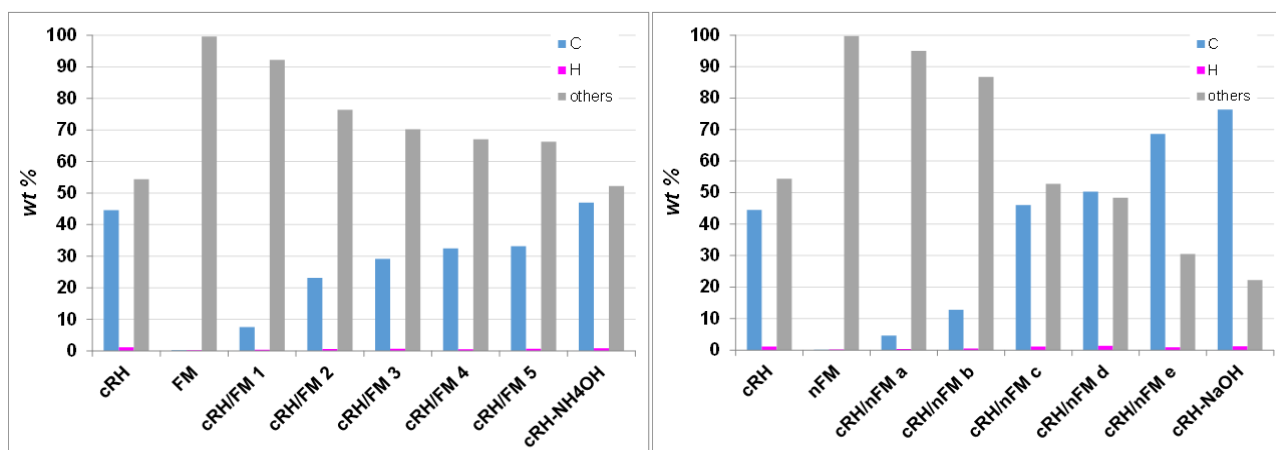


Figure 3. Elemental analysis of samples.

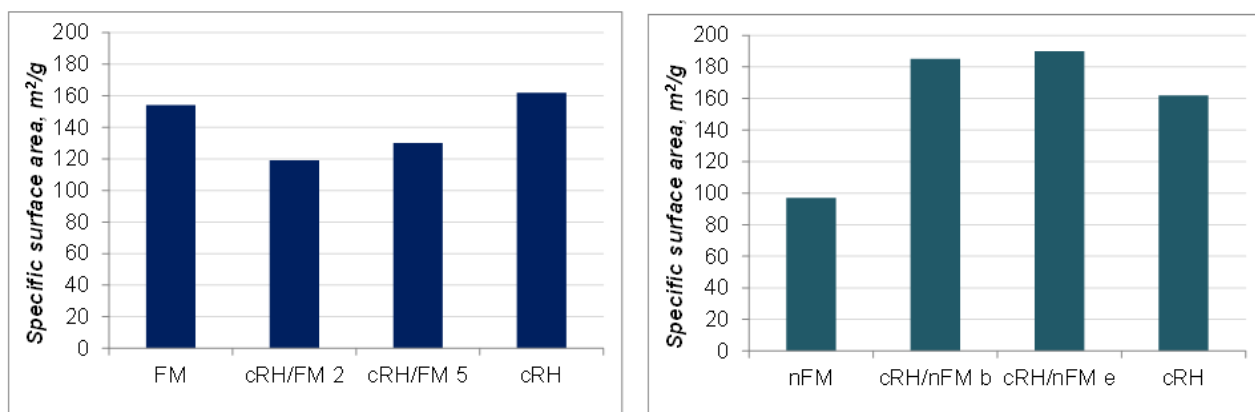


Figure 4. Surface area data.

These measurements were performed at Institute of Research Combustion IRC-CNR, Napoli, Italy (Fig. 5). Pure cRH in comparison with cRH-NaOH corresponded to an increment of 35% of

CO₂ capture capacity (11,26 mg CO₂/g versus 15,31 mg CO₂/g). First of all it is connected with removal of ashes of cRH.

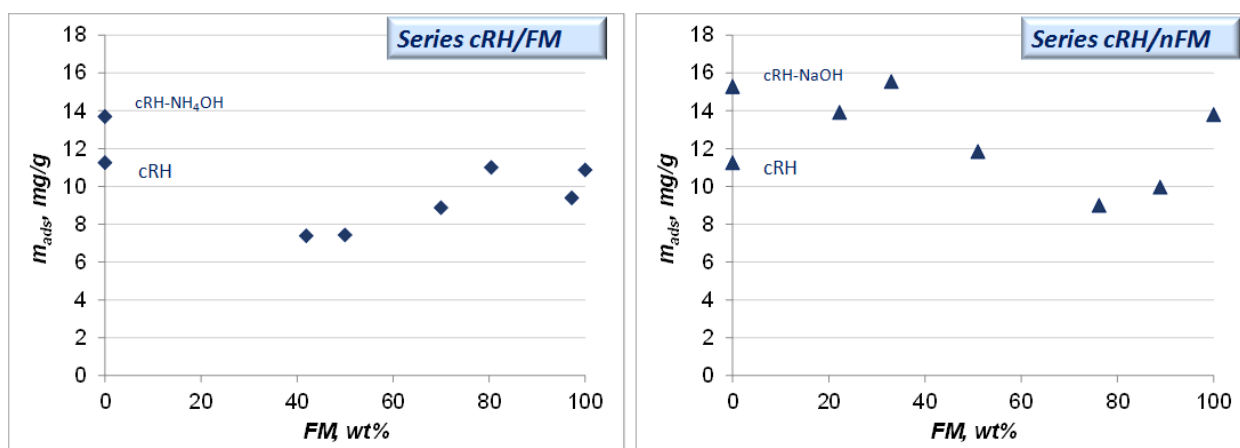


Figure 5. Results of adsorption capacity of the samples from fixed bed microreactor.

Conclusions

These results indicated that the decoration of cRH with FM or nFM did not correspond to an advantageous increment of CO₂ capture capacities. But the removal of ashes corresponded to an increment of 35% of CO₂ capture capacity of cRH. Also the preparation of CO₂ sorbents like composite material based on biomass derived products and ferromagnetite must take into account the presence of ashes and their not adsorbing properties. These preliminary encouraging results find out the possibility to profitably and widely practice cRH as a low cost biomass-derived materials for CO₂ capture.

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**НАНОКОМПОЗИТНЫЙ МАТЕРИАЛ ИСПОЛЬЗУЕМЫЙ В КАЧЕСТВЕ СОРБЕНТА
ДЛЯ УЛАВЛИВАНИЯ ДИОКСИДА УГЛЕРОДА****А. Жумагалиева¹, В. Гаргиуло², Е. Досжанов¹, М. Альфе²**¹Казахский национальный университет имени аль-Фараби,
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assem.zhumagaliyeva@mail.ru**Абстракт**

В данной работе карбонизированная рисовая шелуха использовалась в качестве углеродной твердой матрицы для получения композиционных материалов, модифицированных частицами Fe_3O_4 . Целью данного исследования является использование преимуществ и недостатков использования реальной биомассы в качестве исходного материала для приготовления сорбентов для приложений улавливающих CO_2 . Сорбционную способность полученных композиционных материалов тестировали на микрореакторе с неподвижным слоем.

Ключевые слова: улавливание диоксида углерода, сорбент, рисовая шелуха, оксид железа, микрореактор неподвижного слоя

**КӨМІРТЕГІ ДИОКСИДІН АУЛАУ ҮШІН СОРБЕНТ РЕТІНДЕ НАНОКОМПОЗИТТІ
МАТЕРИАЛДЫ ПАЙДАЛАНУ****А. Жумагалиева¹, В. Гаргиуло², Е. Досжанов¹, М. Альфе²**¹әл-Фараби атындағы Қазақ ұлттық университеті,
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assem.zhumagaliyeva@mail.ru**Аннотация**

Берілген жұмыста композитті материалдарды өндіру үшін карбонизацияланған күріш қабығы Fe_3O_4 бөлшектермен модификацияланған, қатты көміртекті матрица ретінде пайдаланған. Жұмыстың зерттеу мақсаты ретінде CO_2 тұтып қалу үшін шығаратын сорбенттерді дайындау негізінде нақты материалдар биомассаларының артықшылықтары мен кемшіліктерін пайдалану. Алынған композитті материалдардың сорбциялық қасиеттілігін жылжымайтын микрореактор қабатында бақыланды.

Түйін сөздер: көміртек оксидын аулау, сорбент, күріш қабығы, темір оксиді, жылжымайтын микрореактор қабаты.