WATER ADSORPTION STUDY ON THE ZEOLITE LTA GRANULES

Tomaž Fakin[1], Alenka Ristić[1], Andrej Horvat[2], Venčeslav Kaučič[1]

[1]National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia
[2]Silkem d.o.o., Tovarniška cesta 10, 2325 Kidričevo, Slovenia
e-mail: tomaz.fakin@ki.si

ABSTRACT

In the present study we investigated the impact of granulation process on the rate of water adsorption on zeolite granules. We used three types of binders: sodium water glass, bentonite, and boric acid. The influence of binding agents on the physical properties of activated zeolite granules are presented in this paper. We found that varying the concentration of sodium water glass control the water adsorption rate on zeolite granules, while there is no reduction in the adsorption capacity of zeolite.

INTRODUCTION

Zeolites are crystalline aluminosilicates hydrates with a three-dimensional structures which contain voids and/or channels. Rapidly developing field of applications of zeolites is their use as adsorbents, catalysts in the processes of heterogeneous and for heat storage purposes. Many of these applications require the use of compacted forms of zeolites, such as granules.

We present the study of the influence of binders on the physical properties of the activated granulated zeolite. We tested the granules, which were prepared by adding various concentrations of different binders to the zeolite: sodium water glass and natural clays. For the selected granulated samples, the measurements of sorption properties were performed. The manipulation possibilities of the adsorption of the moisture on the zeolite granules, depending on the size of granules, the binder type, and the binder concentration, were studied separately. The compactness and the resistance of the granules to the mechanical forces are essential for the use of the granules in various applications; therefore, a measurement of the forces at which granules broke was conducted in order to evaluate the effectiveness of the binder in the granules.

The material in granular form usually shows poorer physical and chemical properties as the original powder. Restricted diffusion due to less accessible active sites and a smaller fraction of active substances due to addition of binders, are the main disadvantages of the material in granular forms.

EXPERIMENTAL

We have tested and planned a process of granulation of LTA zeolite with an average particle size of 4 μm on the disc granulators. We have tested a variety of equipment available in order to produce granules with the required particle size between 2 mm and 3.15 mm. The manufacturing process of activated granular zeolites consists of three stages: the zeolite conditioning by mixing and moistening, granulation, and the activation of granulated zeolite. Moistening and mixing of zeolite, binding agents and moistening agent was carried out in different types of blenders such as the Ribbon blender, V-blender and Eirich type blender. Granulation was carried out on the granulation plate with a diameter of 1 m. Drying the granules was conducted in a laboratory oven at 105 °C and further activation of the samples in the laboratory calcining kiln for three hours at 500 °C. Measurement of adsorption properties was conducted by measuring the weight change of samples that were exposed to constant humidity RH=55 % and the temperature of 23 °C. The hardness of granules was measured on a device for determining the strength of the particle.

RESULTS AND DISCUSSION

Figure 1 shows that the sorption of water vapor of all granulated samples is about the same in the first two hours, because humidifying external granular layer occurs at this stage and limitations against the transfer of moisture inside the granules do not have a significant impact. In the time interval from 2 hours onward, diffusion of water molecules through a porous mass of zeolite has an increasingly important role; moreover it is already showing the first signs of resistance against the transfer of moisture inside the material. Clearly, the least resistance against moisture transfer shows zeolite powder, while the water adsorption rate decreases with the size of granulates. According to the results, we can conclude that the size of granules does not affect the final sorption capacity of granulates. 4A zeolite powder obtained its sorption maximum after four hours, while the granulate in size between 3.15 mm and 5 mm takes 48 hours for the same adsorption capacity.

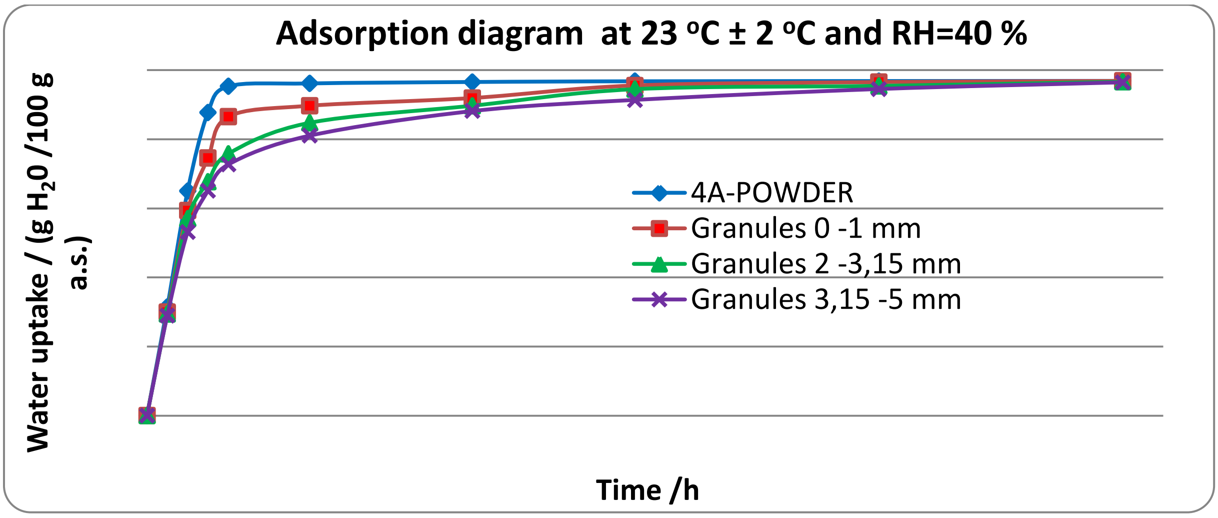

Figure 1: Adsorption diagram for different granules sizes. Granules do not contain binders. The influence of the size of beads on the adsorption is presented.

Figure 2 shows that results vary widely, depending on the type of a binder used. We have found out that the type of the binder plays an important role on the final adsorption capacity of granulates. Thus, in the case of sodium water glass used as the binder, we have observed that the adsorption capacity at 16 % addition of the binder decreases only for 1 % compared to granulate without the binder, which means that sodium water glass does not clog the pores of porous zeolite particles during the granulation process.

In the case of bentonite used as the binder, adsorption capacity of granulates decreases proportionally to the amount of the binder added. That means that the bentonite itself has no adsorption capacity.

In the case of boric acid used as the binder, destructive influence on the adsorption properties of granulates is observed. An addition of 10 % of boric acid already halved the final water adsorption capacity in comparison to granulates with no added binders, 30 % of added boric acid as the binder causes that the granulate do not show any further adsorption properties.

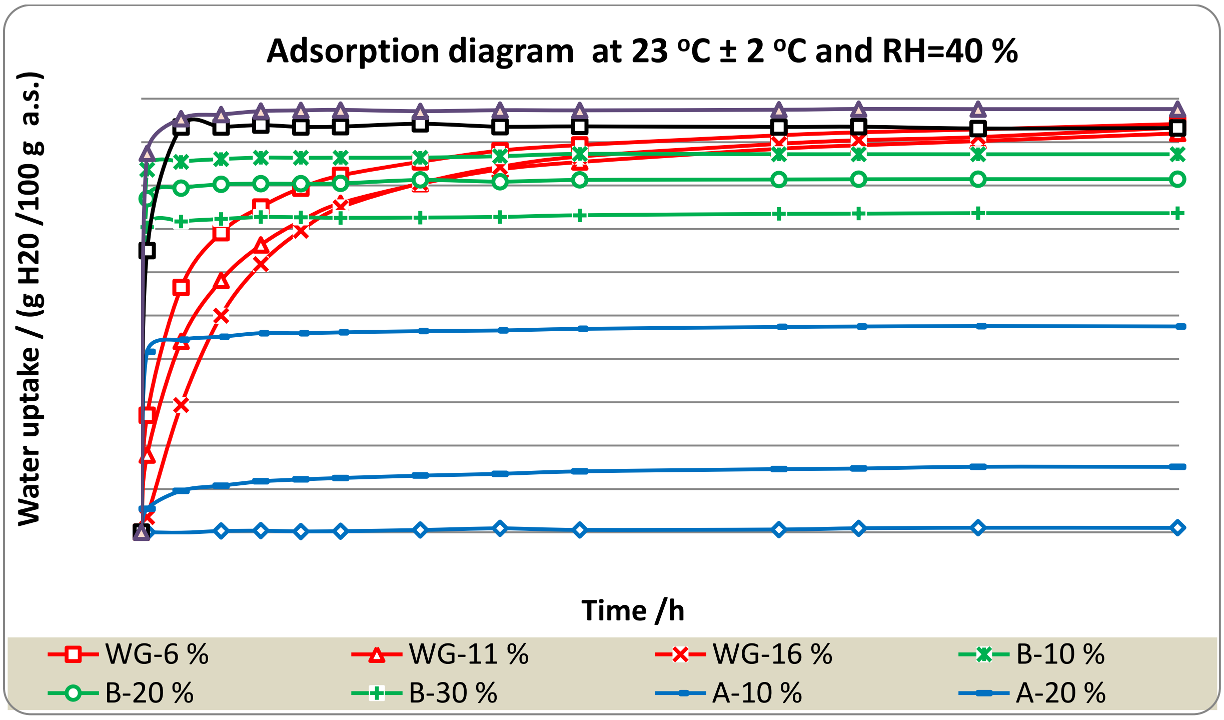

Figure 2: Adsorption diagram of prepared granulates. WG- sodium water glass, B- bentonite, A- Boric acid. In case of samples with sodium water glass as a binder, its contribution to final adsorption capacity of granulates is observed.

Figure 3 shows that the applied forces needed to break the granules in all samples increased after the activation process. This effect is the most obvious in the case of granulates with sodium water glass as a binder, where the forces needed for break granules increased by more than 100 % after the activation process.

The increase in the strength of granulates after the activation process occurs in all samples; also in the sample »None«, which does not contain a binder. This suggests that the zeolite itself with the help of wetting agent improves the strength of granulates after the activation procedure. The reason for such an increase in strength after the activation process is certainly in the physical and chemical changes of the binding agents during the activation process.

The figure 3 also shows that the forces needed to break the granules with sodium water glass as binder excess 30 N. However, it should be noted on the relatively high proportion of the standard deviation for all samples, which is about 20 % of the average value, as a result of an uneven sphericity and the size of the granules.

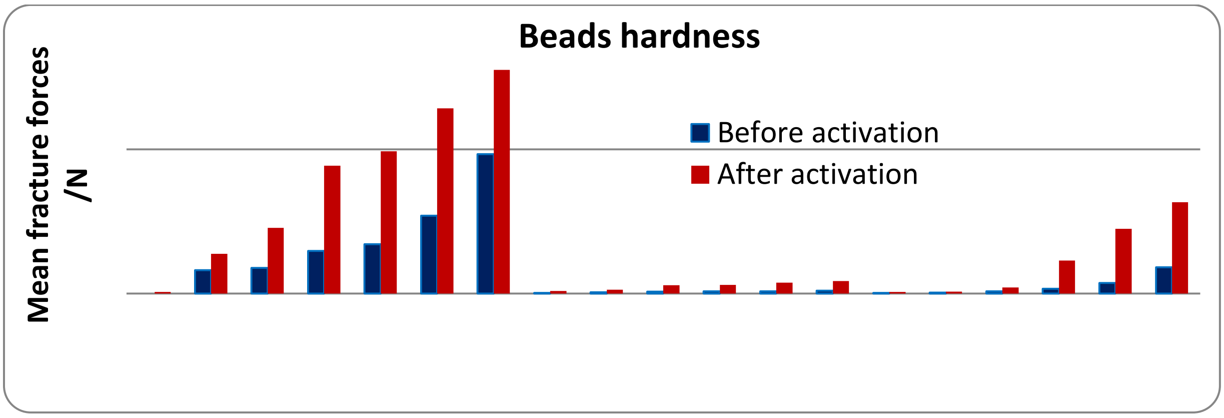

Figure 3: The average hardness of granulates before activation (dryed at 105 °C), and after the activation (calcinated for three hours at 500 °C).

CONCLUSIONS

For the granulation of zeolites, we used three types of binders: sodium water glass, bentonite, and boric acid and prepared granular samples with six different concentrations of each binding agent. On the granular samples in sizes between 2 mm and 3.15 mm, we conducted tests of sorption and strength properties. According to the results we came to the following conclusions:

For the successful granulation process, humidity should be sufficient in material without the occurrence of agglomeration in the mixing stage. This can be achieved by mixing zeolite powder, binder and wetting agent in high-shear blender.

The maximum forces required to break granules are 30 N using a 16 % sodium water glass as a binder. Bentonite does not show the expected features of binder, while the use of boric acid as a binder is acceptable from the viewpoint of the granules strength properties.

The size of granules significantly affects the rate of adsorption only in the first 48-hour period of humidity exposure and does not affect the sorption capacity of granulated material. The highest water adsorption capacity achieves granules with sodium water glass as a binder. Increasing concentrations of sodium water glass in granulates slows down water adsorption, but does not reduce its sorption capacity.

REFERENCES:

[1] J.B. Nagy, P. Bodart, Hannus, and I. Kiricsi, *"Synthesis, charactarization and use of zeolitic microporous materials"*, 1st ed, DecaGen Ltd., Szeged, **1998**, pp. 7-190.

[2] R. H. Perry, *Perry's Chemical Engineer's Handbook*, McGraw-Hill New York, 8th edition, Volume 21, **2008**.