

Activated Magnesium Silicate from Waste Fines from Polishing Process of Lead-Crystal Glass

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Abstract

This study shows the experimental results dealing with recycling of waste fines of the polishing process of the crystal glass (CG) industry. The annual recurring of CG is about 200 tones pa, which contains silica glass. This study shows the recovery of active magnesium meta-silicate. The fines were classified into 4 size cuts. These were fused with Na_2CO_3 powder at temperatures up to 1150°C for different periods. The heated solid was leached in water; whereby sodium metasilicate goes into leachate. Sodium silicate was then reacted with magnesium chloride or sulphate solution to give a white precipitate of magnesium metasilicate. The adsorption properties of the magnesium silicate were determined by the Freundlich adsorption isotherm method. Magnesium metasilicate obtained with chloride salt are more active as compared to that obtained with sulphate. The effect of pH, the concentration of the reactants and the ratio of solid to liquid volume on the properties of the products were studied. Results indicate that the temperature has no effect on the chemical composition of the produced magnesium metasilicate. An amorphous form was first obtained. The activation energy of fusion with sodium salts amounts to 68.44 kJ/mole. The surface area of the magnesium metasilicate increases with the decrease in the concentration of the reactants to attain a value of 75-100 m^2/g .

Keywords: Lead oxide(s), Hydrometallurgy, Magnesium Meta-Silicate, Pyrometallurgy, Surface Area

Introduction

Magnesium silicate is a solid compound white in colour without smell. It is a finely divided powder synthesized by the reaction of water-soluble sodium silicate (water glass) and a water-soluble magnesium chloride, magnesium nitrate or magnesium sulphate. The composition of the compound is a function of the ratio of the components in the reaction medium, the addition of the correcting substances, and the way in which they are precipitated [1-3]. The molecular formula is typically written as $\text{MgO}:\text{XSiO}_2$, where X denotes the average mole ratio of SiO_2 to MgO. The magnesium silicate can be hydrated and its formula can be written $\text{MgO}:\text{X}:\text{SiO}_2 \cdot \text{H}_2\text{O}$ to show the water of hydration. Synthetic magnesium silicates are amorphous and is insoluble in water or alcohol [4]. The naturally occurring magnesium silicate hydroxide is commercially known as talc which is a soft material with waxy feel and nearly soapy in touch. This characteristic has led to name the mineral soapstone [5]. The mineral is alkaline with a pH value of 8.9. Magnesium silicate hydrate (M-S-H) showed after ageing for 1 year exhibited variable compositions with molar Mg/Si ratios

in the range $0.7 \leq \text{Mg/Si} \leq 1$. [6]. Magnesium silicate is used to purify free fatty acids and other polar compounds from used cooking oils and biodiesel by adsorbing free glycerine, soaps, methanol (monoglycerides) and sterol glucosides. Magnesium silicate hydrate silicate is useful for a wide variety of applications: purifying adsorbent (polyols, animal and vegetable oils chromatography, dry cleaning, sugar, resins, odours); filler (rubber, ceramics, paper, glass, refractories); anti-caking agent (salt); catalyst; catalyst carrier; filter medium. Magnesium silicate was prepared by several methods as given by Tayangarian and Emad [7]. Goswami et al., [8]. General speaking, magnesium silicate is prepared by reacting alkali hydroxide with magnesium salt soluble in water.

The aim of this study is to recover magnesium metasilicate from waste fines of the polishing process of lead-crystal glass. The effect of the operation parameters such as temperature, time and pH value on the extent of recovery were investigated.

Materials and Methods

The fines of crystal glass: About 2 kg of the fines generated from the polishing step of crystal glass in an industrial plant in Cairo were obtained from the waste yard, about 200m apart from the

plant location at Shoubra El Khema, Cairo Egypt, (ASF0UR). The sample was washed with water and dried at 110°C for 6 hours. It was further milled and spent fines of the crystal glass as received.



Figure 1: A Photograph of the Waste Fines of Crystal Glass

Chemicals sieved to 4 fractions with different grain sizes. The fines having the size -10 µm

The chemicals used in this study are tabulated in Table 2

Table 2: Properties of the Chemicals Used In This Study

Product	Properties	Purpose	Origin
	Min. assay 36 %		Riedel- de Hein
Nitric acid	Fuming 69 %		ADWIC
H ₂ SO ₄	H ₂ SO ₄ 95-97% Extra pure	Leaching Process	Riedel- de Hein
HCl	SP.GR.1.18 (AR)		ADWIC
Na carbonate,	99.3, 1.6 µm	Synthesis process	Green Egypt Sigma Aldrich
	3.34 g/cm ³ , 1.57 µm		
NaOH (Sodium hydroxide)	reagent grad		United Co. for chemicals & Med. Preparations
Ammonium hydroxide	reagent grad		
distilled water		Chemical reactions	
Tap water		Other purposes	

Determination of Dissolution Extent

The extent of dissolution was computed from; Description of the method for preparation of the end products. Figure 2 shows the conceptual flow sheet of the method applied in this work to prepare the end products

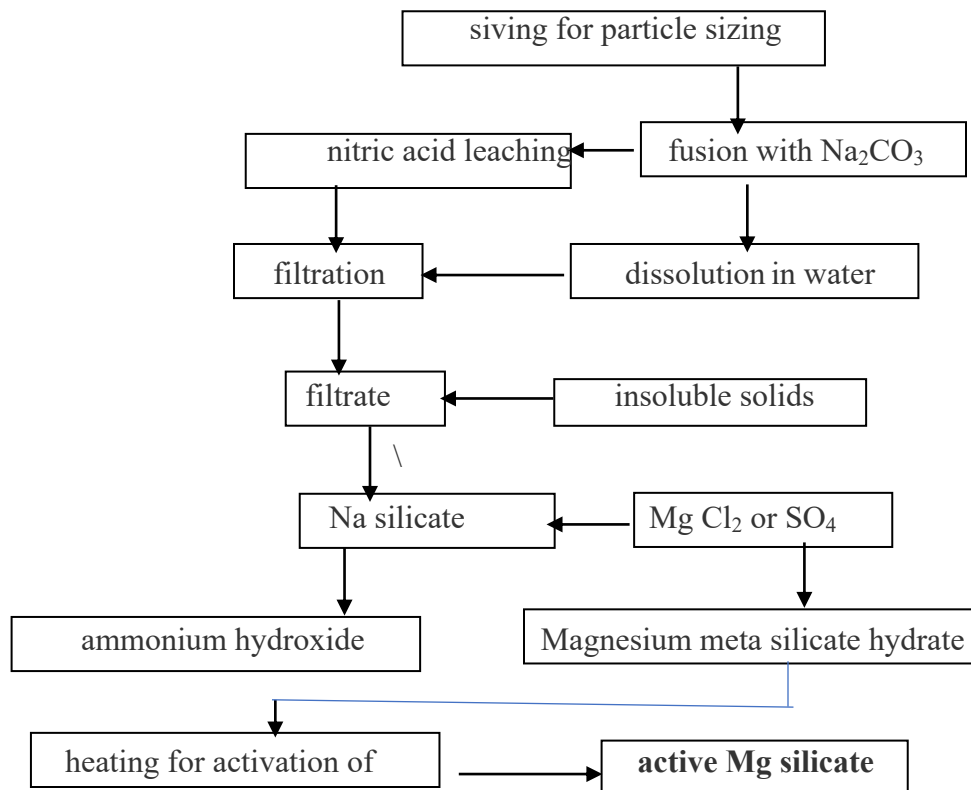


Figure 2: A conceptual flow sheet of the method applied in this work to prepare the end products

Determination of the extent of leaching

The extent of leaching waste fines of crystal glass was determined from the following equation 3.

$$\chi_d = \frac{\text{wt. of the metal in the sample} - \text{wt. of the metal undissolved}}{\text{wt. of the metal in the sample}} \times 100 \quad \dots (3)$$

Determination of silicon

Silicon was determined by XRD, XRF and FTIR analyses.

Results

Table 3 shows the chemical analysis of the spent fines of the polishing process of crystal glass. It can be seen that the main component is silicate (72 wt. %) whereas lead amounts to 24.5 %. Other metals are in minor amounts as determined by the XRF analysis.

Table 3: XRF Analysis of the Spent Fines of Crystal Glass

Element	wt/%
Pb	24.5
SiO ₃	72.6
Na	0.63
K	0.54
Al	0.35
Ca	0.21
Mg	0.37

Fig. 3 shows the effect of liquid :solid ratio on the dissolution extent of fused waste fines with sodium carbonate at 1150 °C for 150 minutes. It is seen that dissolution extent amounts to 48 % with a 1.5 liquid to mass ratio. The extent regularly decreases with the increase of solid to reach a constant value of ≥ 2.5 .

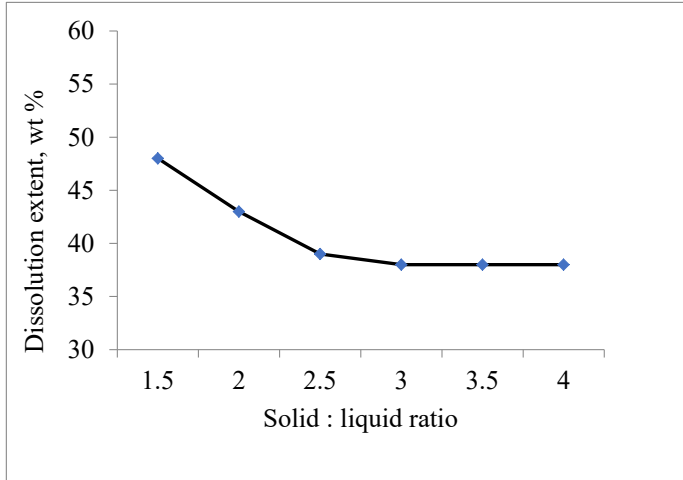


Figure 3: Effect of liquid: solid ratio on the dissolution extent of waste fines

Fig. 4 shows the extent of dissolution of the crystal; glass fines in nitric acid after 6 days as a function of liquid: solid weight ratio. Fig. 5 shows the effect of the sodium silicate module on the extent of its solution of sodium silicate frit. It is seen that the dissolution rate of the frit decreases with the increase in the silicate module to a constant value of ≥ 3.0 . It is also seen that the dissolution rate becomes sensitive to the increase in sodium silicate module > 2.5 .

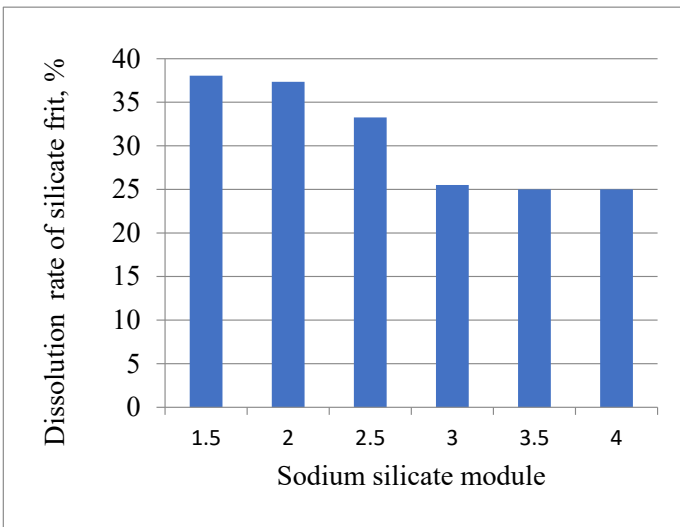


Figure 4: The effect of time on the dissolution of silicate frit

It can be seen that the dissolution rate of sodium silicate frit increases with increase in dissolution time up to 5 hours attaining a constant dissolution rate of 37.95 %.

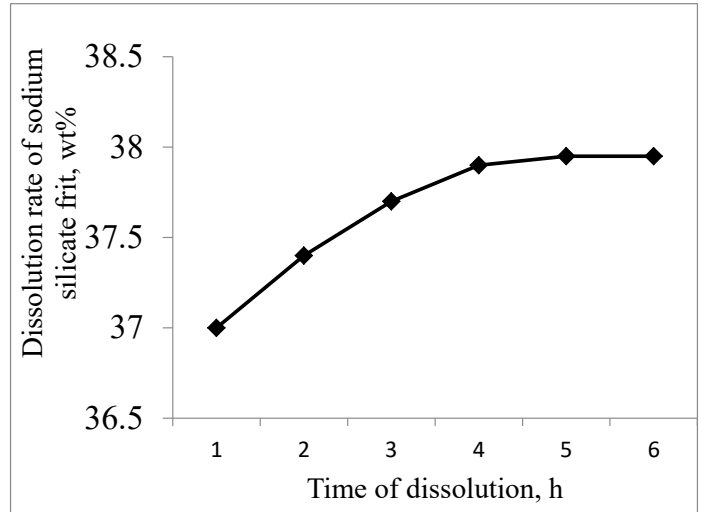


Figure 5: Effect of time on the dissolution rate of sodium silicate frit at 150°C

Magnesium metasilicate was prepared by heating sodium silicate, magnesium sulphate and sodium hydroxide at temperatures up to 1200 °C for 60 minutes. Fig. 6 shows that magnesium silicate are made at 1150 °C-1170 °C. At higher temperature, metasilicate decomposes to magnesium silicate.

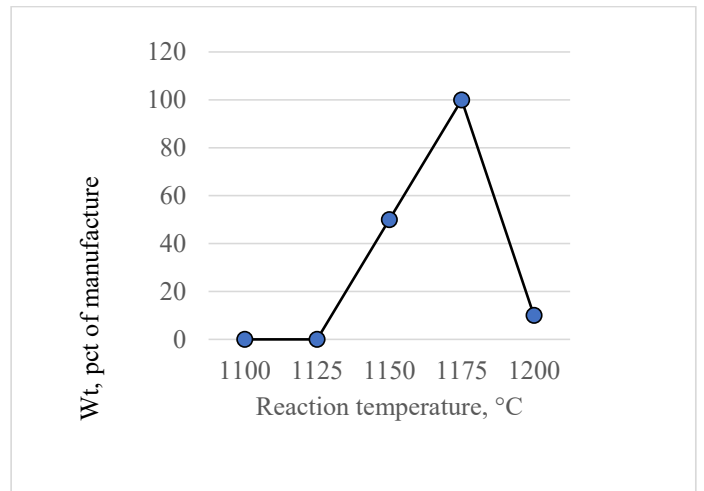


Figure 6: Effect of temperature on the manufacture of magnesium metasilicate.

Discussion

Crystal glass is a type of glass that contain varying amounts of lead oxide. The typical lead crystal composition is: 54-65%, SiO₂ 25-30%, PbO (lead oxide can be partially or totally replaced by barium, zinc or potassium oxide in glasses known as crystal glass), 13-15% Na₂O or K₂O and various other minor components Lead glass, commonly called crystal, is a variety of glass in which lead replaces the calcium content of typical potash glass [9]. Lead glass contains 18–40% (by weight) lead(II) oxide (PbO). Flint glass due to the original silica source, contains a minimum of 24% PbO.

Originally discovered by Englishman George Ravenscroft in 1674, the technique of adding lead oxide (in quantities of between 10 and 30%) improved the properties of glass and made it easier to melt.

The term lead crystal is a glass that lacks a crystalline structure. The term lead crystal remains popular. The addition of lead oxide to glass raises its refractive index and lowers its working temperature and viscosity. The high atomic number of lead also raises the density of the material, since lead has a very high atomic weight of 207.2, versus 40.08 for calcium.

Results of this work are graphically represented in Figs 3 through 5 show that the effect of liquid : solid mass ratio on the dissolution extent of fused waste fines with sodium carbonate at 1150 °C for 150 minutes displayed a higher extent with low solid: liquid ratio. The extent of dissolution is inversely proportionated to that ratio.

Fig. 5 is in line with the model that time is a determinable factor on the dissolution of the fused waste fines of the crystal glass. The maximum extent of dissolution attained after ≥ 5 hours. Metasilicate has the chemical structure:

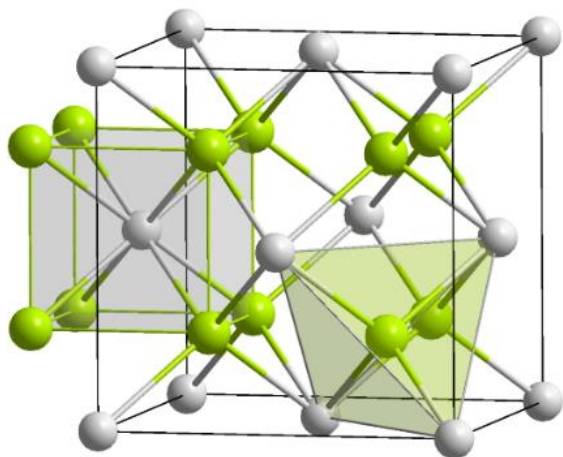


Figure 7: The Chemical Structure of Meta Silicate

It is worthy to note that the manufactured metasilicate decomposes to silicate upon heating to ≥ 1200 °C.

References

1. Boehm, H. P. (1980). The chemistry of silica. Solubility, polymerization, colloid and surface properties, and biochemistry. Von RK Iler. John Wiley and Sons, Chichester 1979. XXIV, 886 S., geb.£ 39.50.
2. Krysztafkiewicz, A., Lipska, L. K., Ciesielczyk, F., & Jesionowski, T. (2004). Amorphous magnesium silicate—synthesis, physicochemical properties and surface morphology. *Advanced Powder Technology*, 15(5), 549-565.
3. Ciesielczyk, F., Krysztafkiewicz, A., & Jesionowski, T. (2007). Physicochemical studies on precipitated magnesium silicates. *Journal of materials science*, 42(11), 3831-3840.
4. Van Nostrand and Reinhold Co. Inc., (1987). *Condensed Chemical Dictionary*, Eleventh Edition, New York, NY.
5. Google me, “The properties of magnesium silicate”, June 2022.
6. Nied, D., Enemark-Rasmussen, K., L’Hopital, E., Skibsted, J., & Lothenbach, B. (2016). Properties of magnesium silicate hydrates (MSH). *Cement and Concrete Research*, 79, 323-332.
7. Tavangarian, F., & Emadi, R. (2010). Synthesis of pure nanocrystalline magnesium silicate powder. *Ceramics-Silikaty*, 54(2), 122-127.
8. Goswami, M., Mirza, T., Sarkar, A., Manikandan, S., Verma, S. L., Gurusurthy, K. R., ... & Kothiyal, G. P. (2000). Preparation and characterization of magnesium-aluminium-silicate glass ceramics. *Bulletin of Materials Science*, 23(5), 377-382.
9. Hu, B., & Hui, W. (2018). Lead recovery from waste CRT funnel glass by high-temperature melting process. *Journal of hazardous materials*, 343, 220-226.

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