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A Renewable Source of Silica

Introduction

Silica gel is a versatile material, commonly found as beads in sachets. It is a crucial product used as a desiccant to control humidity to avoid spoilage or degradation of goods[1]. The current sourcing of silica, quartz, is extremely detrimental to workers but is continued to be used due to its abundance and affordability. A study has discovered a potential alternative source for this issue called rice husk ash (RHA). This prevalent material is a safer, renewable, and economically stable source of silica[2]. This report will explore the application and development of silica production and its influences on society.

Science Background

Silica gel is a form of silicon dioxide (SiO_2) made of 1 silicon atom covalently bonded to 2 oxygen atoms. It is an amorphous, porous solid as seen in figure 1 that allows it to be a great absorbent. The main process for manufacturing this material is by precipitation in which aqueous solutions of sodium metasilicate and a mineral acid react under high temperature in alkaline conditions[3]. The gelatinous precipitate formed is rinsed with water to remove the soluble materials, and then dehydrated to produce opaque granular pieces of silica gel.

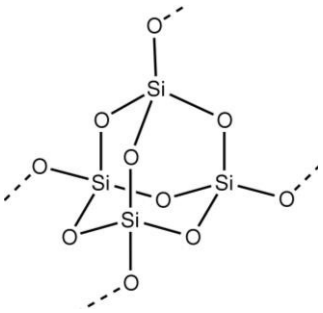

Figure 1: Chemical structureof SiO_2.

Approximately 120 million tonnes of rice husks (RH) are produced annually[4]. Many rice-producing countries use RH to generate energy by combustion, resulting in the by-product of RHA. A simple method for extracting pure silica from RHA was developed where the RHA is dissolved in an alkali solution which forms a sodium silicate solution. Hydrochloric acid is then combined to lower the pH level, producing silica gels[5].

Economic and Environmental Implications

The primary source of silica is currently quartz due to its abundance simple processing and inexpensiveness[6]. Workers are exposed to exceedingly harmful side effects from the crystalline silica released during the extraction of silica from this material. Many of these fatalities are irreversible and only exacerbate over time[7]. Respirable silica exposure has been linked to the development of autoimmune diseases and cardiovascular damage. These are life-altering and severe conditions that impact millions of workers each

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[1] Micro-Pak. (2022). *The Importance of Eliminating Silica Gel - Micro-Pak*. [online] Available at: https://www.micropakltd.com/en/news/the-importance-of-eliminating-silica-gel [Accessed 21 March. 2023].

[2] Prasad, R. and Pandey, M. (2012). Rice Husk Ash as a Renewable Source for the Production of Value Added Silica Gel and its Application: An Overview. *Bulletin of Chemical Reaction Engineering & Catalysis*, [online] 7(1). doi:https://doi.org/10.9767/bcrec.7.1.1216.1-25. [Accessed 21 March. 2023].

[3] Fujisilysia.com. (2013). *Silica-gel Manufacturer | Fuji Silysia Chemical*. [online] Available at: https://www.fujisilysia.com/technology/#:~:text=Precipitated%20silica%20is%20manufactured%20by,flocculation%20into%20the%20alkaline%20liquid. [Accessed 21 March. 2023].

[4] Kumar Das, S., Adediran, A., Rodrigue Kaze, C., Mohammed Mustakim, S. and Leklou, N. (2022). Production, characteristics, and utilization of rice husk ash in alkali activated materials: An overview of fresh and hardened state properties. *Construction and Building Materials*, [online] 345, p.128341. doi:https://doi.org/10.1016/j.conbuildmat.2022.128341. [Accessed 25 March. 2023].

[5] Lima, S.P.B. de, Vasconcelos, R.P. de, Paiva, O.A., Cordeiro, G.C., Chaves, M.R. de M., Toledo Filho, R.D. and Fairbairn, E. de M.R. (2011). Production of silica gel from residual rice husk ash. *Química Nova*, [online] 34(1), pp.71–75. doi:https://doi.org/10.1590/s0100-40422011000100014. [Accessed 25 March. 2023].

[6] Minerals Education Coalition. (2018). *Silica - Minerals Education Coalition*. [online] Available at: https://mineralseducationcoalition.org/minerals-database/silica/#:~:text=Also%20called%20silica%20sand%20or%20quartz%20sand%2C%20silica%20is%20made,%2C%20quartzite%2C%20is%20another%20source. [Accessed 25 March. 2023].

[7] Osha.gov. (2016). *Silica, Crystalline - Health Effects | Occupational Safety and Health Administration*. [online] Available at: https://www.osha.gov/silica-crystalline/health-effects [Accessed 26 March. 2023].

year. Quartz is also a non-renewable source meaning an alternative source will need to eventually be found meeting the same or better standards as this[8].

In current society, major industries are working to transition to renewable resources since limited resources will ultimately deplete and are consequently unreliable sources. As RHA is a renewable resource, silica production can become partially renewable as it can be produced unlike quartz. Therefore, instead of relying entirely on finite resources, expanding the silica production by depending on renewable will increase the abundance of RHA for silica extraction. Rice is the world's largest food production enterprise and is the staple food for more than half of the world's population. Yet, for every tonne of rice produced, more than 0.23 tonnes of RH are produced, making RHA incredibly accessible[9]. This by-product is typically utilised as fuel for steam engines or boiling paddy, heavily contributing to environmental pollution, and harming the surrounding land it is disposed onto. Organic RH has 22.12% SiO_2 but it is burned for fuel by farmers, RHA is formed, which contains 85%-95% amorphous silica[10]. This means that RH, rather than being a pollutant, could be utilised to produce the high-value silica, hence reducing its function as an environmental impact.

Using RHA to manufacture silica is the most economic as a great additional cost is not required to acquire this material. Due to the great abundance of RHA in producing countries, silica extraction is a highly inexpensive and therefore more economical secondary source for silica. Moreover, RHA is a highly efficient source of silica. While current sources like granite have only 45-50% of silica and quartz contains up to 93%, RHA contains 85%-95%, making it a more viable secondary source[11]. Further, RHA also does not expose workers to crystalline silica eliminating the previous manufacturing health implications mentioned.

Moreover, as RH has a low nutritional content and is rich in silica, it takes a long time to decompose, making it unsuitable for composting and manure. Hence, storing RH and RHA has a significant negative impact on the environment if not properly disposed of. Although burning RH still contributes to greenhouse gas emissions, extracting silica from the ashes reduces the environmental footprint created from the poor disposal methods of RHA[12]. As a result, extracting silica from an industrial by-product reduces its characteristic as an environmental pollutant while repurposing it to be recycled into a high-value commodity.

Application and Relevance

This newfound renewable silica source is a step forward in the utilisation of industrial by-products for high-end commodities such as silica, reducing global waste and strengthening the economy. This innovative concept is gaining traction in the manufacturing business and represents an essential step for renewable sourcing. Additionally, the possibilities for RHA silica are limitless. As well as the afore-mentioned use of preserving clothes and foods, this silica is ideal for use in polymeric materials, as a substitute for condensed silica fume in concrete, in ceramics, glassware and in insulation refractories[13]. Since RHA contains more than 90% amorphous silica, it is extremely sustainable, renewable, and reliable, and has the potential to replace the usage of less sustainable, finite sources.

Conclusion

This new renewable source of silica is an exciting advancement for the manufacturing industry. As industries continue to grow, researchers have been on the search for safer, renewable, and inexpensive alternative source for silica. Hence, RHA silica is not only more cost-effective and convenient, but it is also extremely environmentally friendly and launches a new pathway in the silica-production industry.

Word Count: 935

[8] Journal of Asian Ceramic Societies. (2018). Rice husk/rice husk ash as an alternative source of silica in ceramics: A review. [online] Available at: https://www.tandfonline.com/doi/full/10.1080/21870764.2018.1539210 [Accessed 26 March. 2023].

[9] Arjmandi, R., Hassan, A., Majeed, K. and Zakaria, Z. (2015). Rice Husk Filled Polymer Composites. *International Journal of Polymer Science*, [online] 2015, pp.1–32. doi:https://doi.org/10.1155/2015/501471. [Accessed 26 March. 2023].

[10] ResearchGate. (2015). *Table 1 : Composition of silicon according to EDS analysis for silicon...* [online] Available at: https://www.researchgate.net/figure/Composition-of-silicon-according-to-EDS-analysis-for-silicon-wafer-silicon-from-silica_tbl1_294086109 [Accessed 26 March. 2023].

[11] Cdc.gov. (2014). *Silica Hazards from Engineered Stone Countertops | Blogs | CDC*. [online] Available at: https://blogs.cdc.gov/niosh-science-blog/2014/03/11/countertops/ [Accessed 26 March. 2023].

[12] Roguel, S., Malasa, R. and Tanzo, I. (2002). of Muñoz. *Philippine Journal of Crop Science*, [online] 27(3), pp.53–58. Available at: https://www.cabi.org/gara/FullTextPDF/2009/20093019269.pdf.

[13] Stevulova, N., Junak, J. and Vaclavik, V. (2018). Effect of Silica Fume as a Component of Alternative Binder on the Selected Technically Important Characteristics of Bio-Aggregate-Based Composites. *Materials*, [online] 11(11), p.2153. doi:https://doi.org/10.3390/ma11112153.

References

Arjmandi, R., Hassan, A., Majeed, K. and Zakaria, Z. (2015). Rice Husk Filled Polymer Composites. *International Journal of Polymer Science*, [online] 2015, pp.1–32. doi:https://doi.org/10.1155/2015/501471. [Accessed 26 March. 2023].

Cdc.gov. (2014). *Silica Hazards from Engineered Stone Countertops | Blogs | CDC*. [online] Available at: https://blogs.cdc.gov/niosh-science-blog/2014/03/11/countertops/ [Accessed 26 March. 2023].

Fujisilysia.com. (2013). *Silica-gel Manufacturer | Fuji Silysia Chemical*. [online] Available at: https://www.fujisilysia.com/technology/#:~:text=Precipitated%20silica%20is%20manufactured%20by,flocculation%20into%20the%20alkaline%20liquid. [Accessed 21 March. 2023].

Journal of Asian Ceramic Societies. (2018). Rice husk/rice husk ash as an alternative source of silica in ceramics: A review. [online] Available at: https://www.tandfonline.com/doi/full/10.1080/21870764.2018.1539210 [Accessed 26 March. 2023].

Kumar Das, S., Adediran, A., Rodrigue Kaze, C., Mohammed Mustakim, S. and Leklou, N. (2022). Production, characteristics, and utilization of rice husk ash in alkali activated materials: An overview of fresh and hardened state properties. *Construction and Building Materials*, [online] 345, p.128341. doi:https://doi.org/10.1016/j.conbuildmat.2022.128341. [Accessed 25 March. 2023].

Lima, S.P.B. de, Vasconcelos, R.P. de, Paiva, O.A., Cordeiro, G.C., Chaves, M.R. de M., Toledo Filho, R.D. and Fairbairn, E. de M.R. (2011). Production of silica gel from residual rice husk ash. *Química Nova*, [online] 34(1), pp.71–75. doi:https://doi.org/10.1590/s0100-40422011000100014. [Accessed 25 March. 2023].

Micro-Pak. (2022). *The Importance of Eliminating Silica Gel - Micro-Pak*. [online] Available at: https://www.micropakltd.com/en/news/the-importance-of-eliminating-silica-gel [Accessed 21 March. 2023].

Minerals Education Coalition. (2018). *Silica - Minerals Education Coalition*. [online] Available at: https://mineralseducationcoalition.org/minerals-database/silica/#:~:text=Also%20called%20silica%20sand%20or%20quartz%20sand%2C%20silica%20is%20made,%2C%20quartzite%2C%20is%20another%20source. [Accessed 25 March. 2023].

Osha.gov. (2016). *Silica, Crystalline - Health Effects | Occupational Safety and Health Administration*. [online] Available at: https://www.osha.gov/silica-crystalline/health-effects [Accessed 26 March. 2023].

Prasad, R. and Pandey, M. (2012). Rice Husk Ash as a Renewable Source for the Production of Value Added Silica Gel and its Application: An Overview. *Bulletin of Chemical Reaction Engineering & Catalysis*, [online] 7(1). doi:https://doi.org/10.9767/bcrec.7.1.1216.1-25. [Accessed 21 March. 2023].

ResearchGate. (2015). *Table 1 : Composition of silicon according to EDS analysis for silicon...* [online] Available at: https://www.researchgate.net/figure/Composition-of-silicon-according-to-EDS-analysis-for-silicon-wafer-silicon-from-silica_tbl1_294086109 [Accessed 26 March. 2023].

Roguel, S., Malasa, R. and Tanzo, I. (2002). of Muñoz. *Philippine Journal of Crop Science*, [online] 27(3), pp.53–58. Available at: https://www.cabi.org/gara/FullTextPDF/2009/20093019269.pdf.

Stevulova, N., Junak, J. and Vaclavik, V. (2018). Effect of Silica Fume as a Component of Alternative Binder on the Selected Technically Important Characteristics of Bio-Aggregate-Based Composites. Materials, [online] 11(11), p.2153. doi:https://doi.org/10.3390/ma11112153.