Potential applications for a silica sand sample

Short Report

211613463

for

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Executive Summary

On June 02, 2020 Dorfner Analysenzentrum und Anlagenplanungs-gesellschaft mbh ("ANZAPLAN"), having its registered office in Hirschau, Germany, was retained by Select Sands, having its registered office in Vancouver, Canada, to carry out a screening program for evaluating "Potential applications for a silica sand" by ANZAPLAN quotation 211613463. Two samples of silica sand were sent for the analytical test work program in the amount of approximately 130 kg of fraction 40/140 mesh and 1 kg of fraction 40/70 mesh. The samples arrived at ANZAPLAN´s premises in Hirschau on April 30, 2020.

Findings:

Sample fraction 40/140 mesh shows an iron oxide content of 0.0154 wt.-% while having a titanium oxide grade of 0.01 wt.-%. Sample fraction 40/70 mesh presents a higher iron oxide concentration (0.0276 wt.-%) while having a lower titanium content (<0.005 wt.-%).

For silica sand applications, a wide range of chemical compositions and particle size distributions depending on the final application apply. Based on the chemical composition of both samples and their particle size (40/140 mesh and 40/70 mesh), options for potential applications were considered.

In addition to frac sand which is the application that the material is currently sold into the following applications are conceivable:

- Silica for silicon carbide, fused silica and sodium silicate
- Filtration sand
- Glass sand for various applications, e.g.:
    - Container glass (colored)

- Container glass (clear)
- Float glass (window, automotive)
- Fiberglass (insulation and fabrics)

Specifications for silica sand used in glass applications present a strict limit regarding iron oxide, which was analyzed in this evaluation. Additionally the particle size distribution influences the smelting properties of the sand. Fraction 40/140 mesh will be favored by the glass industry due to reduced energy consumption as compared to fraction 40/70 mesh.

Beside particle size and iron content, further criteria are important for glass applications, which were not tested. Those tests and analytics would be a prerequisite for further evaluating the applicability of the silica sand samples as glass sand:

- Analysis of heavy minerals
- Analysis of coloring elements

Beside the mentioned applications, following applications may be conceivable after further processing.

- Quartz powder/ ground silica (grinding step necessary)
  - In ceramic bodies as non-plastic material
  - In production of glazes and engobes for ceramics
  - Filler in plastics, epoxy resin and rubber improving durability and performance
  - In paints and varnishes where silica offer hardness and abrasion resistance
- In the construction industry in a wide range of applications, e.g. flooring/screed, internal and external plaster, dry mortar, concrete, polymer concrete, aerated concrete or sand-lime brick.

Such products are typically marketed locally and are adjusted specifically to the needs of the potential customers and its applications. Specifications and specific requirements should be discussed in advance with potential customers to develop a customized product supported by specific analytical, processing and application tests.

Recommendations:

From all considered applications, the glass sand application is the most prominent application by volume. Higher valued glass sand applications exist but require a reduced iron content. Therefore, test work including density separation, flotation and magnetic separation focusing on the purity of the glass sand, especially the iron content, is recommended.

In order to verify the usability of the sand products, further analyses of existing and purified products after test work are recommended. Those analyses would include further coloring elements (Cr, Co, Cu, Mn, Ni, V) and the amount of heavy mineral particles in the sand.

A market study is recommended to evaluate the detailed market potential locally of the different products as well as estimated product sales prices.

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1 Introduction

On June 02, 2020 Dorfner Analysenzentrum und Anlagenplanungs-gesellschaft mbh ("ANZAPLAN"), having its registered office in Hirschau, Germany, was retained by Select Sands America Corporation, having its registered office in Houston, Texas, to carry out the test work program "Determination of application for a silica sand" by ANZAPLAN quotation 211613463. Two samples of silica sand were sent for the analytical test work program in the amount of approximately 130 kg of fraction 40/140 mesh and 1 kg of fraction 40/70 mesh. The samples arrived at ANZAPLAN´s premises in Hirschau on April 30, 2020.

Target of the report was to evaluate the market applicability of the two samples with regard to their chemical composition.

The results of the analytical test work are summarized in the present report.

2 Applied techniques and procedures

2.1 X-Ray diffraction

Samples were characterized by X-ray diffraction (XRD) (Bruker, D8 advance) according to DIN EN 13925 2003-07. The crystalline phases were identified by using the JCPDS data base (INTERNATIONAL CENTER FOR DIFFRACTION DATA) and verified by an expert.

2.2 Chemical Analysis

The main element composition was analyzed on representative samples by X-ray fluorescence spectroscopy (XRF, S8 Tiger by Bruker AXS) according to DIN EN ISO 12677 2013-02.

2.3 Loss on ignition

Loss on ignition was determined according to DIN EN ISO 12677 2013-02 at a temperature of 1,025°C in a muffle furnace.

3 Analyses and results

3.1 Chemical analysis

Chemical analyses show, that both samples have a very high silica content, while having only minor impurities. The impurities of major importance for glass applications are Fe and Ti. Sample fraction 40/140 mesh has an iron content of 0.0154 wt.-% while having a titanium concentration of 0.01 wt.-%. Sample fraction 40/70 mesh has a higher iron concentration (0.0276 wt.-%) while having a lower titanium content (<0.005 wt.-%). The complete chemical analysis of the two samples is listed in Table 1.

Table 1: Chemical composition of the two received samples

Chemical Analyses	SiO_2 [wt.-%]	Al_2O_3 [wt.-%]	Fe_2O_3 [wt.-%]	K_2O [wt.-%]	Na_2O [wt.-%]	TiO_2 [wt.-%]	CaO [wt.-%]	MgO [wt.-%]	BaO [wt.-%]	LOI 1,025 °C [wt.-%]
Select Sands fraction 40/140 mesh	99.7	0.07	0.0154	0.01	<0.02	0.01	<0.01	<0.01	<0.01	0.12
Select Sands fraction 40/70 mesh	99.6	0.05	0.0276	<0.01	<0.02	<0.005	0.02	<0.01	<0.01	0.19

3.2 Mineralogical analysis

Both samples were analyzed via XRD to determine the mineralogical composition. The analysis is illustrated in Figure 1 (fraction 40/140 mesh) and Figure 2 (fraction 40/70 mesh).

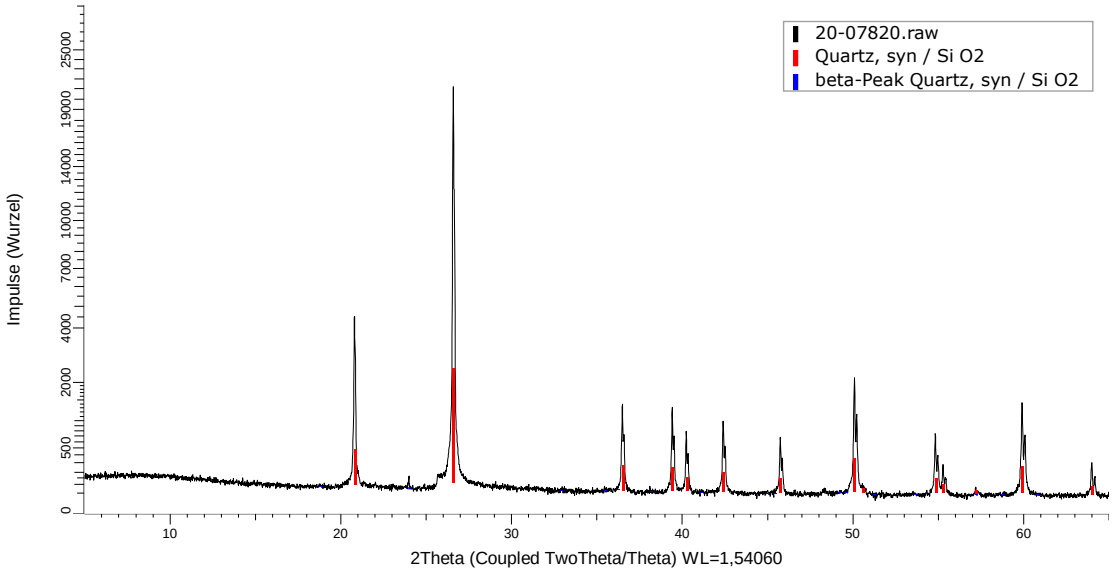

Figure 1: Mineralogical analysis of sample fraction 40/140 mesh

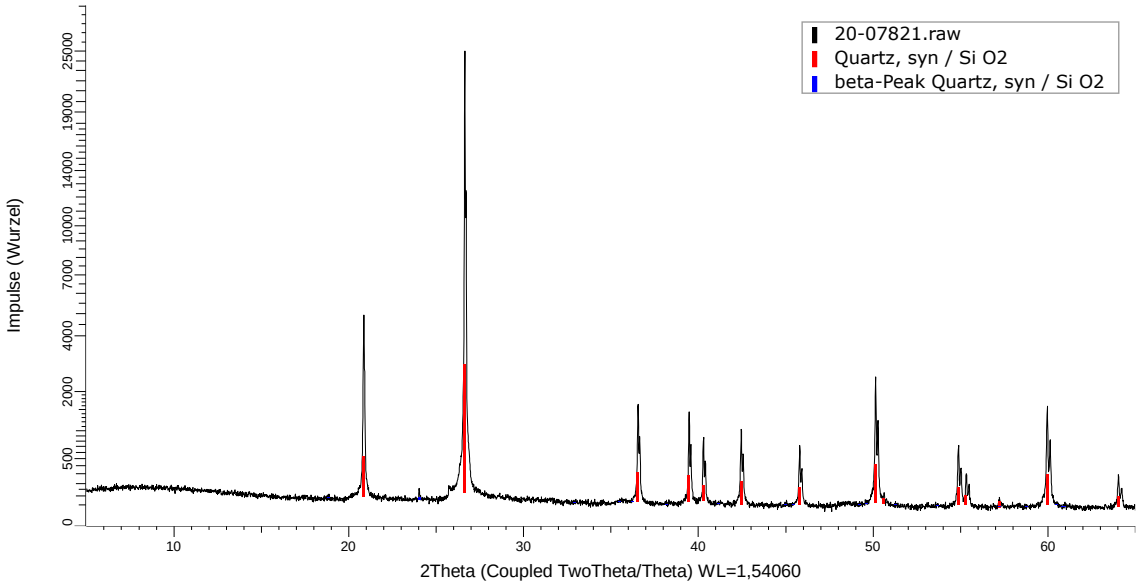

Figure 2: Mineralogical analysis of sample fraction 40/70 mesh

XRD patterns evidence the presence of quartz as major mineral phase in both samples.

3.3 Particle size distribution

Both fractions (40/140 mesh and 40/70 mesh) are in principle suitable for glass sand application regarding their particle size. Since the particle size distribution affects the smelting properties of the silica sand (energy consumption), fraction 40/140 mesh will be favored by the glass industry over fraction 40/70 mesh.

4 Conclusion

Sample fraction 40/140 mesh shows an iron oxide content of 0.0154 wt.-% while having a titanium oxide grade of 0.01 wt.-%. Sample fraction 40/70 mesh presents a higher iron oxide concentration (0.0276 wt.-%) while having a lower titanium content (<0.005 wt.-%).

For silica sand applications, a wide range of chemical compositions and particle size distributions depending on the final application apply (cf. Table 2). Based on the chemical composition of both samples and their particle size (40/140 mesh and 40/70 mesh), options for potential applications were considered.

The following applications are conceivable additionally to the application as frac sand, for which the sand is already applied to (cf. Table 3):

- Silica for silicon carbide, fused silica and sodium silicate
- Filtration sand
- Glass sand for various applications, e.g.:
    - Container glass (colored)
    - Container glass (clear)
    - Float glass (window, automotive)
    - Fiberglass (insulation and fabrics)

Specifications for silica sand used in glass applications presents a strict limit regarding iron oxide, which was analyzed for this evaluation. Above that the particle size distribution influences the smelting properties of the sand. Therefore fraction 40/140 mesh will be more excepted by the glass industry due to reduced energy consumption than fraction 40/70 mesh.

Beside particle size and iron content, further criteria are important for glass applications, which were not tested for the present evaluation. Those tests and analytics would at least be necessary to further evaluate the applicability of the silica sand samples as glass sand:

- Analysis of heavy minerals
- Analysis of coloring elements

Beside the mentioned applications, following applications may be conceivable after further processing.

- Quartz powder/ ground silica (grinding step necessary)
    - In ceramic bodies as non-plastic material
    - In production of glazes and engobes for ceramics
    - Filler in plastics, epoxy resin and rubber improving durability and performance
    - In paint and varnishes where silica offer hardness, abrasion resistance
- In building industry in a wide range of applications, e.g. flooring/screed, internal and external plaster, dry mortar, concrete, polymer concrete, aerated concrete or sand-lime bric

Such products are typically marketed locally and are adjusted specifically to the needs of the potential customers and its applications. Specifications and specific requirements should be discussed in advance with potential

customers to develop a customized product supported by specific analytical, processing and application tests.

Recommendations:

From all considered applications, the glass sand application is the most prominent application by volume. Higher valued glass sand applications exist but require a reduced iron content. Therefore, test work including density separation, flotation and magnetic separation focusing on the purity of the glass sand, especially the iron content, is recommended.

In order to verify the usability of the sand products, further analyses of existing and purified products after test work are recommended. Those analyses would include further coloring elements (Cr, Co, Cu, Mn, Ni, V) and the amount of heavy mineral particles in the sand.

A market study is recommended to evaluate the detailed market potential locally of the different products as well as estimated product sales prices.

Table 2: Standard specifications for silica sand applications

Application	SiO_2 [wt.-%]	Al_2O_3 [wt.-%]	Fe_2O_3 [wt.-%]	TiO_2 [wt.-%]
Container glass (colored)	> 98.9	< 0.15	< 0.15	< 0.10
Container glass (clear)	> 99.5	< 0.10	< 0.035	< 0.02
Float glass (window, automotive)	> 99.5	< 0.15	< 0.04	< 0.04
Fiberglass (insulation)	> 98.1	< 0.52	< 0.50	< 0.05
Fiberglass (fabrics)	> 99.2	< 0.60	< 0.04	< 0.05
Borosilicate glass, pyrex	> 99.0	< 0.20	< 0.015	< 0.01
White float glass, opal glass, Crystal glass	> 99.0	< 0.20	< 0.0125	< 0.01
Solar glass	> 99.0		< 0.01	< 0.02
Borofloat			< 0.007	
Quartz powder	> 98.5		< 0.03	
Engineered stone	> 99.5			
Silicon carbide	> 99.0			
Fused silica	> 99.5		< 0.02	
Sodium/ Potassium silicate	> 99.0		< 0.02	

Table 3: Suitability of the two samples in regard to their chemical composition and further test work recommendations

Applications	Container glass (colored)	Container glass (clear)	Float glass (window, automotive)	Fiberglass (insulation)	Fiberglass (fabrics)	Borosilicate glass, pyrex	White float glass, opal glass, crystal glass	Solar glass	Borofloat	Quartz powder	Engineered stone	Silicon carbide	Fused silica	Sodium/ Potassium silicate	Frac sand	Filtration sand
Select Sands fraction 40/140 mesh	+; 1	+; 1	+; 1	+	+	(+); 1; 4	(+); 1; 4	-; 1; 4	-; 1; 4	+; 2; 3	+; 5	+; 2	+; 2	+; 2	+; 2	+; 2
Select Sands fraction 40/70 mesh	+; 1	+; 1	+; 1	+	+	-; 1; 4	-; 1; 4	-; 1; 4	-; 1; 4	+; 2; 3	+; 5	+; 2	+; 2	+; 2	+; 2	+; 2

Chemical composition suitability rating	
+	*suitable for the application regarding chemical composition*
-	*not suitable for the application regarding chemical composition*
(+)	*limited suitability regarding chemical composition*
Further test work recommended	
1	*Analysis of heavy minerals*
2	*Application tests*
3	*Grinding tests*
4	*Test work to reduce Fe_2O_3 and/or TiO_2 content*
5	*Uniform color test*

5 Disclaimer

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