Porous Geopolymer Materials for Different Applications

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Latvia

Riga (founded in 1201)

64589 km²
1.93 milj. people
Raw materials:
Aluminium Scrap Recycling Wastes

Chemical composition:
- $\text{Al}_2\text{O}_3$ 63.19%
- $\text{SiO}_2$ 7.92%
- $\text{CaO}$ 2.57%
- $\text{MgO}$ 4.43%
- $\text{Fe}_2\text{O}_3$ 4.54%
- $\text{K}_2\text{O}$ 2.75%
- $\text{Na}_2\text{O}$ 3.84%
- Others 6.95%

Raw materials:
- q - quartz (83-2187)
- f - iron oxide (32-0469)
- s - spinel (75-1799)
- ● - aluminium iron oxide (18-0633)
- ■ - calcium aluminium iron oxide (21-0830)
- ♦ - magnesium aluminium silicate (30-0788)
- g - gibsite (70-2038)
Raw materials:
Clays (aluminium silicate source)

1. Calcined Illite clay
2. Metakaolin (industrial by-products produced by «Stiklaporas» Ltd., Lithuania)
3. Low Qality Chammotite («Keramserviss» Ltd., Latvia)
4. Firebrick sawing residues («Morgan Thermal Ceramics» Ltd., UK)
Raw materials:
Glasses (additional silicate source)

1. Bore-silicate lamp glass

2. Two type of glasses - E-glass and K-glass, by-products (overlefts) from glass fibre production
   («Valmieras Stiklašķiedra» Ltd., Latvia)
Production of Porous Geopolymer Materials

Properties depend on the oxide ratio: $\text{SiO}_2/\text{Al}_2\text{O}_3$; $\text{SiO}_2/\text{Na}_2\text{O}$; $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$

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<thead>
<tr>
<th></th>
<th>min</th>
<th>max</th>
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<tbody>
<tr>
<td>$\text{SiO}_2/\text{Al}_2\text{O}_3$</td>
<td>0.77</td>
<td>2.50</td>
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<tr>
<td>$\text{SiO}_2/\text{Na}_2\text{O}$</td>
<td>3.10</td>
<td>5.08</td>
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<tr>
<td>$\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$</td>
<td>0.17</td>
<td>0.67</td>
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Production of Porous Geopolymer Materials

1. Preparation of raw materials: 80 °C, 24 h
2. Dosage of solid raw materials
3. Add activator
4. Porous structure formation
5. Curing
6. Demolding
7. Application
8. Mixing

Sodium silicate solution

Composition

Fillers

Pore formation additive

Calcined clay

SiO$_2$ additive
Macro and microstructure of Porous Geopolymer Materials
Porous Geopolymer granules - catalysts for pH adjustment

• Chemically un-bounded alkalis remains in the microstructure of Porous Geopolymer Materials after their preparation.
• Porous structure of Porous Geopolymer Materials with specific pore size and distributions ensures long lasting and steady leaching process of un-bounded alkalis. Thereof pH of media increases in time.
• The optimal teat treatment temperature is 200 °C to ensure long time adjustment of pH.
Porous Geopolymer granules - catalysts for pH adjustment

\[
\sum \text{OH}^- (\text{mol} / (l \cdot gSAS))
\]

Days

118.09 m²/g
87.69 m²/g
82.23 m²/g
43.02 m²/g
10.16 m²/g
10.12 m²/g
7.36 m²/g
1.01 m²/g

IC-A-SG1
IC-A-SG0
IC-A-SG1-200
IC-A-SFG1-400
IC-T-SG1
IC-T-SG0
IC-T-SG1-200
IC-T-SG1-400
Porous Geopolymer granules - catalysts for pH adjustment
Porous Geopolymer granules - catalysts for biogas production systems

- Porous Geopolymer granules could be used as new progressive porous material for pH control without automatic pH controlling systems;
- Biogas yield increased up to 30% in batch tests;
- Porous Geopolymer granules are favorable environment for bacteria growing.

The changes of the pH level in solution which is used in the biogas digestion process

Buffer capacity in solution which is used in the biogas digestion process
Growth of bacteria on Porous Geopolymer granules during biogas digestion
Porous Geopolymer granules for heavy metal (Pb and Zn) removal from wastewater

Lead removal efficiency with Porous Geopolymer granules and Pb mapping

Zinc removal efficiency with Porous Geopolymer granules and Zn mapping
Porous Geopolymer granules for heavy metal (Pb and Zn) removal from wastewater

Zn containing film (~2% Zn) on surface of the Porous Geopolymer granule
Porous Geopolymers - heat insulation materials for industrial application

Q - quartz (85-0798)
M - mullite (01-0613)
C - corundum (71-1124)
Cr - cristobalite (03-0267)
- hydroxy sodalite (31-1271)
- carnegieite (11-0220)
- nepheline (83-2372)

0.5K-1000°C
0.5K-800°C
0.5K
0.5K-raw

Compressive strength, MPa
Flexural strength, MPa

Without heat treatment
Heat treatment at 800°C
Heat treatment at 1000°C
Porous Geopolymers - heat insulation materials for industrial application
Porous Geopolymers - heat insulation materials for industrial application
Geopolymer binders with increased content of zeolites

- Zeolites are synthesized at hydrothermal conditions;
- Raw materials contained amorphous oxides of aluminum and silica are used. They can be natural minerals or wastes / by-products from different industry;
- Zeolites are ensuring ion exchange, catalysis, and adsorption.
- Natural or artificial zeolites can be added to the composition of Geopolymers to improve catalytic properties.
Thank you for your attention!