obtained for the band at 950 cm^{-1}, the band shifts toward a lower wave number after geopolymerization, suggesting a change in the microstructure of the mine tailings and the production of new aluminosilicate geopolymers.

The band with a peak at 720 cm^{-1} is attributed to the symmetric stretching of Si–O–Si and Al–O–Si bonds in an aluminosilicate framework. The band does not exist for the starting mine-tailings source but appears in all three samples after geopolymerization with alkali, suggesting that some new aluminosilicate geopolymer is induced. Therefore, the peak at ~720 cm^{-1} is a specific "fingerprint" of the geopolymer matrix indicating that the polymeric precursors — [SiO_4] and [AlO_4] tetrahedral — had formed a cross-linking aluminosilicate framework, condensed further and finally formed geopolymers.

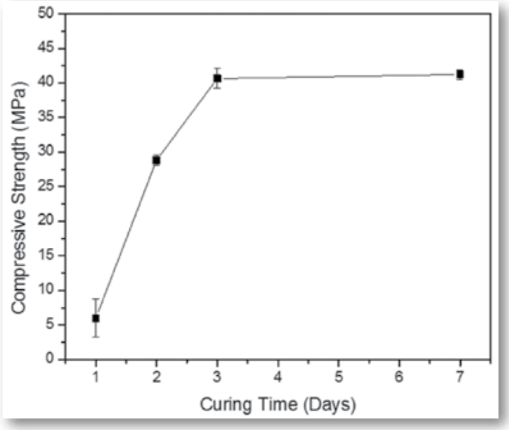

Fig. 1 Relationship between compressive strength and curing time.

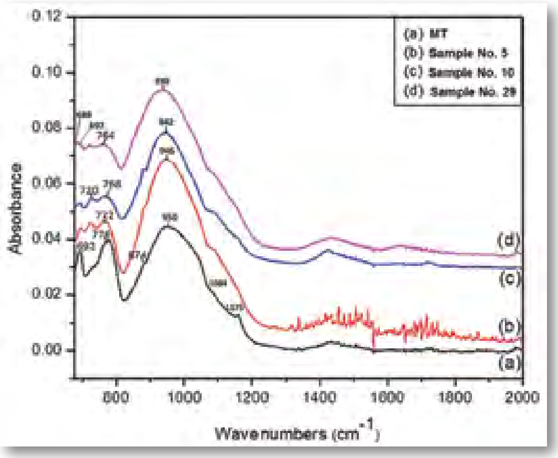

Fig. 2 FTIR spectra of MT and geopolymer specimen: (a) activated with NaOH only, (b) with 5 percent $Ca(OH)_2$ added, (c) with 5 percent $Ca(OH)_2$ and 0.2 percent reacted Al_2O_3 added.

Conclusions

Experimental results show that the compressive strength in the geopolymerization production of mine tailings increases evidently to about 40.7 MPa. The stress–strain behavior of the geopolymerization specimen is similar to that of concrete, and the dynamic modulus is 22.15 GPa. The SEM/EDS analysis results suggest that applying forming pressure will not only make products compact by reducing voids, but decrease both sodium (Na) concentration and the Si/Al ratio. Both reasons account for a high compressive strength, as achieved with a forming pressure being applied. The results of FTIR and XRD analyses showed that the microstructure of mine tailings changes and new geopolymers are produced after geopolymerization. ■

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Use of the field-based silica monitoring technique in a coal mine: A case study

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To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Respirable crystalline silica (RCS) found in dust generated by various mining processes is an important occupational hazard in the underground coal-mining industry. Exposure can lead to disabling and incurable diseases, including coal

workers' pneumoconiosis (CWP), silicosis and lung cancer [1,2]. Clusters of rapidly progressive CWP have been observed in the Appalachian regions of eastern Kentucky and southwestern Virginia, and recent cases have been generally more severe and showing more rapid progression. CWP is approximately four times as common among long-tenured underground coal miners in central Appalachia than long-tenured underground miners in the rest of the United States, and 20.6 percent of long-tenured underground miners in central Appalachia were suffering from the disease as of 2017.

Background

Monitoring samples from central Appalachia have shown high quartz content and small particle size relative to coal mine dust from other regions [3]. Additionally, quartz content in respirable dust varies widely among sections in the same mine, among mining occupations, and day to day in the same mine section [3,4]. The continuous personal dust monitor (CPDM), a required monitoring tool in coal mines, is unable to differentiate between quartz and other dust content, and RCS concentration is only loosely linked to the concentration of overall respirable dust [4,5]. The current monitoring approach for RCS relies on collecting dust samples using the coal-mine dust personal sampler unit (CMDPSU), then sending the samples for laboratory analysis off-site.

The U.S. National Institute for Occupational Safety and Health (NIOSH) has developed a field-based method to monitor respirable crystalline silica that can generate results at the mine after the work shift. The method uses a portable Fourier-transform infrared (FTIR) spectrometer to analyze samples collected using the CMDPSU and has previously been used successfully with other cassette types [6]. To implement the method, the portable spectrometer is set up at the site, along with a PC computer loaded with NIOSH FAST (Field Analysis of Silica Tool) software. To analyze each sample, the operator removes the cassette from its plastic case and places it into the spectrometer, where the instrument collects the spectrum and analyzes for the signature features of crystalline silica and kaolinite, a correctable analytical confounder. The measurement is nondestructive, allowing the samples to be retained for storage and further analysis, if desired, and takes less than two minutes per sample to complete. The operator inputs the file created by the spectrometer's software along with sampling time and pump flow rate into the NIOSH FAST software, which calculates RCS concentration.

Method

To test the field-based RCS monitoring approach, NIOSH collaborated with a coal-mine operator near Charleston, WV, where the research team conducted a two-part case study. For each part, the mining company's safety personnel proposed a question about miners' RCS exposure, then designed and executed an appropriate sampling plan to investigate it using respirable dust samples collected on the CMDPSU. The first part of the case study, conducted in late 2016 through early 2017, investigated the effect on RCS concentration of adding a commercially available surfactant additive to the onboard dust-suppression water sprays on two underground mechanized mining units. Workers applied four different levels of surfactant (100, 75, 50 and 0 percent dissolve rates) to the water spray while the continuous miners were operating and collected samples at each continuous miner and in the returns, four times for each condition over multiple work days. The second part of the case study, conducted in late 2017, compared differences in RCS exposure for workers assigned to various mine occupations. Workers collected a set of seven area samples positioned to represent various job tasks (continuous miner, roof bolter, scoop, center shuttle car and outside shuttle car) as well as intake and return air, at each of 11 mine sections across four closely located coal seams. NIOSH scientists completed field-based analysis and gravimetric analysis on all samples. Subsequently, a representative subset of samples was sent to an external laboratory for analysis by the U.S. Mine Safety and Health Administration (MSHA) P-7 method.

Results and discussion

For the first part of the case study, results generated by the field-based method as well as the MSHA P-7 method both yielded an interpretation that the presence of surfactant was not found to reduce RCS concentration. Similarly, in the second part, the analysis methods both returned a consistent trend with respect to RCS exposure by occupation. The results obtained by the MSHA P-7 method were compared by weighted least squares linear regression to the results obtained by the field-based method, and the paired measurements were found to show strong linear correlation, with correlation coefficients of 0.92 and 0.90 for the first and second parts, respectively. The regression equations determined suggest a mild tendency to overestimate the actual crystalline silica present, with a statistically significant overestimate found for the first part at the 95 percent confidence level. Consistent with prior studies showing substantial variability, the silica content of the dust was found to range from 2.7 to 28.9 percent.

While the overall trends shown by the field-based method were consistent with those shown by the MSHA P-7 method, individual measurements did show substantial deviation (up to around 100 percent) from their MSHA P-7 values. As a trade-off inherent in its nondestructive method, the field-based approach relies on a prediction of the deposition of dust on the cassette. This prediction of the deposition, while well established for some other cassette types, can be inconsistent for the CMDPSU and results in increased uncertainty. As an alternative, a commercially available, FTIR-compatible, four-piece cassette avoids this limitation.

Conclusion

The results of this study support the use of the field-based method with the CMDPSU for determining relative trends of RCS exposure, but with the limitation that measurements can be quite variable from sample to sample. Overall, the field-based method can be useful for the type of engineering and process-improvement purposes attempted in the case study. Due to the high variability of crystalline silica content in respirable coal-mine dust, implementation of field-based crystalline silica monitoring could provide more accurate information on potential respirable crystalline silica exposure in a faster timeframe than standard MSHA P-7 analysis. ■

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Flotation froth image segmentation based on highlight correction and parameter adaptation

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Keywords: Froth flotation, Image segmentation, Watershed algorithm, Parameter adaptive

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

The level of automation employed in flotation production is relatively low. In an actual concentrator, operators use their judgment to adjust the production state based on the visual characteristics of the flotation froth surface. There are shortcomings, such as strong subjectivity and lagging process operation, that easily cause the waste of manpower and material resources. Machine vision technology is introduced to replace human visualization, achieving a

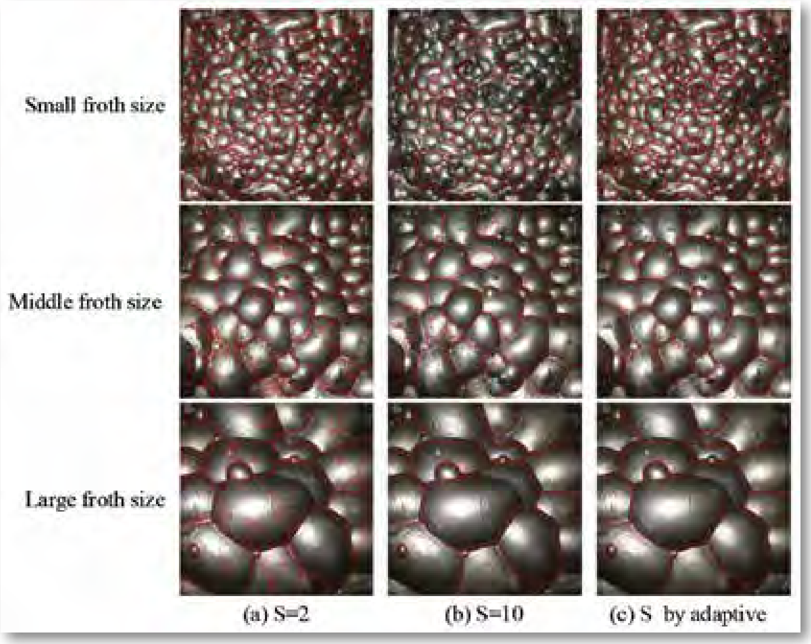

Fig. 1 Segmentation results of parameters of different structural elements.