マテリアル先端リサーチインフラ利用報告書
ARIM User's Report

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課題データ / Project Data

課題番号 Project Issue Number	23KU1015
利用課題名 Title	Effect of goethite (α-FeOOH) nanoparticles on the surface properties and flotation behavior of chalcopyrite
利用した実施機関 Support Institute	九州大学
機関外・機関内の利用 External or Internal Use	内部利用（ARIM事業参画者以外）/Internal Use (by non ARIM members)
横断技術領域 Cross-Technology Area	計測・分析/Advanced Characterization 物質・材料合成プロセス/Molecule & Material Synthesis
重要技術領域 Important Technology Area	次世代ナノスケールマテリアル/Next-generation nanoscale materials 革新的なエネルギー変換を可能とするマテリアル/Materials enabling innovative energy conversion
キーワード Keywords	Iron-based nanoparticles, goethite, chalcopyrite, flotation, nanodepressant,電子顕微鏡/ Electronic microscope,ナノ粒子/ Nanoparticles

利用者と利用形態 / User and Support Type

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利用形態 Support Type	機器利用/Equipment Utilization,技術補助/Technical Assistance

利用した主な設備 / Equipment Used in This Project

利用した主な設備 Equipment ID & Name	KU-501：電子状態測定システム KU-511：走査電子顕微鏡装置群

報告書データ / Report

概要（目的・用途・実施内容） Abstract (Aim, Use Applications and Contents)	Chalcopyrite flotation is selectively depressed by oxidation treatment. The presence of ferric oxyhydroxide on the surface of chalcopyrite after oxidation treatment is a key factor in depressing chalcopyrite flotation. However, there is no concrete evidence that ferric oxyhydroxide has a depressing effect. In addition, the effectiveness of this depressing effect could be enhanced by directly applying ferric oxyhydroxide nanoparticles. This study investigated the effect of goethite (α-FeOOH) nanoparticles on the surface properties and flotation behavior of chalcopyrite. α-FeOOH nanoparticles were produced through chemical precipitation followed by hydrothermal treatment. The crystalline structure of irregular rice grain-shaped α-FeOOH nanoparticles was confirmed by the X-ray diffraction pattern and scanning electron microscope image. Micro-flotation experiments showed that chalcopyrite recovery decreased significantly from 93 % to 13 % when 30 mg/L α-FeOOH nanoparticles was used. This flotation result demonstrated the potential of α-FeOOH nanoparticles as a nanodepressant for the flotation of chalcopyrite. These nanoparticles physically adsorbed on the chalcopyrite surface and rendered its surface hydrophilic, thereby reducing the chalcopyrite flotation recovery. The attractive electrostatic force between the positively charged α-FeOOH nanoparticles and the negatively charged chalcopyrite surface is likely responsible for the adsorption of α-FeOOH nanoparticles on chalcopyrite.
実験 Experimental	This study produced α-FeOOH nanoparticles using the chemical precipitation method followed by hydrothermal treatment. Fe(III) solution was prepared by dissolving 3.4 g of Fe(NO3)3.9H2O in 50 mL of ultrapure water. The pH condition of Fe(III) nitrate solution was increased by immediately adding 18 mL of 5 M NaOH solution and vigorously stirring for 3 h. Afterward, the suspension was poured into a Teflon-lined stainless-steel autoclave. The hydrothermal treatment was then performed at 120 ∘C for 12 h (WFO-520, Eyela, Tokyo, Japan). Subsequently, the autoclave was cooled down to room temperature. The suspension was then centrifuged at 7000 rpm for 10 min (TOMY SRX201, TOMY Digital Biology Co. Ltd., Tokyo, Japan) and washed with ultrapure water. The final product was dried at 60 ∘C for 12 h. The X-ray diffraction (XRD) pattern of α-FeOOH nanoparticles was analyzed to determine the crystallinity of the α-FeOOH nanoparticles using Ultima 4 (Rigaku, Japan), operated at 40 mA and 40 kV. The morphology and microstructure of α-FeOOH nanoparticles were studied using scanning electron microscopy (SEM) analysis (FlexSEM 1000 II, Hitachi High-Tech, Japan). The surface topography of α-FeOOH nanoparticles was analyzed using atomic force microscopy (AFM) (NanoNavi S-image, Seiko Instruments Inc., Japan). The α-FeOOH nanoparticles were dispersed in ultrapure water by ultrasonic treatment for 1 min (Yamato 3510, Branson, Japan) to produce a suspension of 30 mg/L α-FeOOH nanoparticles. A drop of this α-FeOOH nanoparticle suspension was placed on the polished surface of chalcopyrite. The surface was dried under ambient conditions and then used as an AFM sample. The size distribution and zeta potential of α-FeOOH nanoparticles were measured using Zetasizer Nano ZS (Malvern Co. Ltd., UK). X-ray photoelectron spectroscopy (XPS) was used to identify the chemical state of the α-FeOOH nanoparticles (Shimadzu–Kratos Co. Ltd., UK). The spectra for XPS analysis were calibrated using C 1s at 285.0 eV.

結果と考察 Results and Discussion	The effect of goethite (α-FeOOH) nanoparticles on the flotation behavior of chalcopyrite and the potential of these nanoparticles as a chalcopyrite depressant were investigated in this study. The synthesis of goethite (α-FeOOH) nanoparticles by chemical precipitation methods and hydrothermal treatment produced irregular rice grain shapes of crystalline α-FeOOH nanoparticles. The flotation experiments demonstrated that 30 mg/L of α-FeOOH nanoparticles depleted chalcopyrite recovery at pH 9. This result demonstrates the potential of α-FeOOH nanoparticles as a nanodepressant for the flotation of chalcopyrite. The detrimental effect of α-FeOOH nanoparticles on the flotation recovery of chalcopyrite is caused by the adsorption of positively charged α-FeOOH nanoparticles on the negatively charged surface of chalcopyrite. The adsorbed α-FeOOH nanoparticles rendered the chalcopyrite surface hydrophilic, thus reducing its floatability.
図・表・数式 Figures, Tables and Equations	
その他・特記事項（参考文献・謝辞等） Remarks(References and Acknowledgements)	This work was supported by a Grant-in-Aid for Science Research (JSPS KAKENHI) from the Japan Society for the Promotion of Science (JSPS) – Japan [Grant numbers JP22K14636, JP19H02659, and JP22H00310]. The X-ray photoelectron spectroscopy analysis was supported by the “Advanced Research Infrastructure for Materials and Nanotechnology in Japan (ARIM)” of the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) of Japan [Grant number JPMXP1222KU1009].

成果発表・成果利用 / Publication and Patents

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