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研究报告

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# 温度与pH对生物合成施氏矿物在酸性环境中溶解行为及对$Cu^{2+}$吸附效果的影响

# Influence of temperature and pH on dissolution behavior of biogenic Schwertmannite in acidic environment and the adsorption of $Cu^{2+}$

关键词：温度 pH 生物成因 施氏矿物 溶解行为 $Cu^{2+}$

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摘要：探析施氏矿物在不同温度、pH下的溶解行为,对其在酸性煤矿废水(ACMD)重金属去除领域的应用具有重要的工程指导意义.本研究通过摇瓶实验,在0.16 mol·$L^{-1}$ $FeSO_4 \cdot 7H_2O$,初始pH为2.5的酸性体系中,采用氧化亚铁硫杆菌*A. ferrooxidans*催化合成施氏矿物.考察了15 ℃与30 ℃,pH为2.0~6.0环境条件下矿物的溶解行为,及生物合成施氏矿物对酸性体系$Cu^{2+}$的吸附去除效果.研究结果表明,经过24h反应,施氏矿物合成体系pH从原始2.50降低至2.18,体系$Fe^{2+}$氧化完全,27.3%的铁离子参与矿物的合成,矿物分子式可表示为$Fe_8O_8(OH)_{4.22}(SO_4)_{1.89}$.生物合成施氏矿物在温度为15 ℃,pH分别为3.2、3.0、2.8、2.6、2.4、2.2与2.0液态体系中振荡72 h,矿物溶解率分别为1.92%、3.34%、5.90%、13.09%、28.74%、44.53%与61.46%. 在温度为30 ℃的上述酸度体系中,矿物溶解率在相应时间却达到2.04%、3.98%、8.34%、20.53%、43.50%、96.74%与99.92%.在pH≥3.5的不同温度液态体系中该矿物无溶解迹象.在15 ℃,pH为6.0、5.0、4.5、4.0与3.5,$Cu^{2+}$浓度为40 mg·$g^{-1}$的液态体系中,生物合成施氏矿物对$Cu^{2+}$的吸附量为(50.9±2.2)、(47.3±13.3)、(40.5±4.7)、(31.1±5.0)及(16.9±6.5) mg·$g^{-1}$.体系酸度一定,施氏矿物在15 ℃与30 ℃条件下对$Cu^{2+}$的吸附效果无显著差异.本研究结果对生物合成施氏矿物在ACMD重金属去除工程应用提供必要的参数支撑.

**Abstract**: To remove heavy metals from acidic coal mine drainage (ACMD), it is important to understand the effect of pH and temperature on the dissolution behavio of biogenic schwertmannite in acidic environment. In this study, biogenic schwertmannite was synthesized through the oxidation of ferrous iron and subsequent hydrolysis facilitated by *A. ferrooxidans* in the solution of 0.16 mol·$L^{-1}$ $FeSO_4 \cdot 7H_2O$ with pH 2.5. The dissolution behavior of schwertmannite and Cu sorption by schwertmannite in the solution with different pH (2.0~6.0) and temperatures (15 ℃ and 30 ℃) were investigated. The results showed that ferrous ions could be completely oxidized by *A. ferrooxidans* after 24h incubation. The solution pH decreased from 2.50 to 2.18, and 27.3% of iron ions was incorporated into schwertmannite. Molecular formula of schwertmannite could be expressed as $Fe_8O_8(OH)_{4.22}(SO_4)_{1.89}$. Biogenic schwertmannite dissolution percentages reached 1.92%, 3.34%, 5.90%, 13.09%, 28.74%, 44.53%, and 61.46% after 72 h shaking in pH 3.2, 3.0, 2.8, 2.6, 2.4, 2.2, and 2.0 solution at 15 ℃, respectively. However, wher temperature increased to 30 ℃, the percentages greatly increased to 2.04%, 3.98%, 8.34%, 20.53%, 43.50%, 96.74%, and 99.92%, respectively. It was noted that schwertmannite was not dissolved in the solution with pH ≥3.5 under all temperatures. In addition, the sorption amount of $Cu^{2+}$ could reach (50.9±2.2), (47.3±13.3), (40.5±4.7), (31.3±5.0), and (16.9±6.5) mg·$g^{-1}$ at 15 ℃ in pH 6.0, 5.0, 4.5, 4.0, and 3.5 acidic systems with 40 mg·$L^{-1}$ $Cu^{2+}$. In the same acidic solution systems, significant differences at 15 ℃ and 30 ℃ for the sorption amount of $Cu^{2+}$ by schwertmannite were not observed.

**Key words**: temperature pH biogenic Schwertmannite dissolution behavior $Cu^{2+}$