

3.2 Cyclic voltammogram

The cyclic voltammogram curves of galena under natural pH condition, pH 12 adjusted by NaOH and by lime respectively are presented in Fig. 3. It can be seen from Fig. 3 that anodic peak emerges at a potential of about 0. These phenomena may correspond to the following reaction:

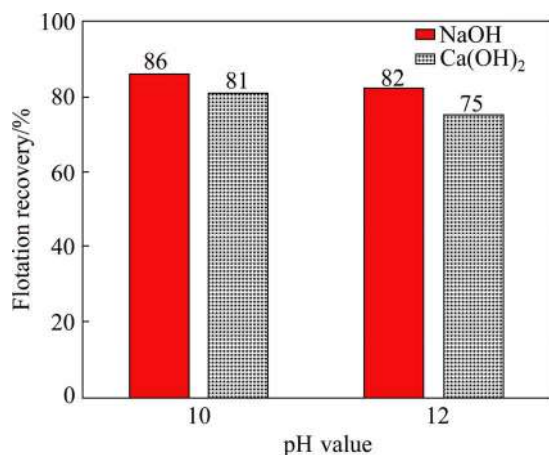


Fig. 1 Effect of pH value on flotation recovery of galena with NaOH and Ca(OH)₂ as regulators at 25 °C and DDTC concentration of 1×10^{-4} mol/L

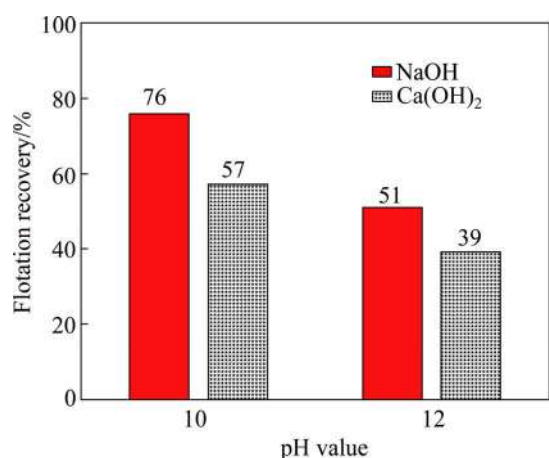


Fig. 2 Effect of pH value on recovery of jamesonite with NaOH and Ca(OH)₂ as regulators at 25 °C and DDTC concentration of 1×10^{-4} mol/L



Galena itself can be oxidized to Pb^{2+} and S at pH 6.82. As the generation of PbD_2 in the system occurs simultaneously with oxidation of galena, there may have another reaction:



The anodic oxidation peaks of galena and PbD_2 almost overlap in high alkali pump with low scanning potential. The oxidation product of galena is HPbO_2^- and S, so, the reaction of generation of PbD_2 is

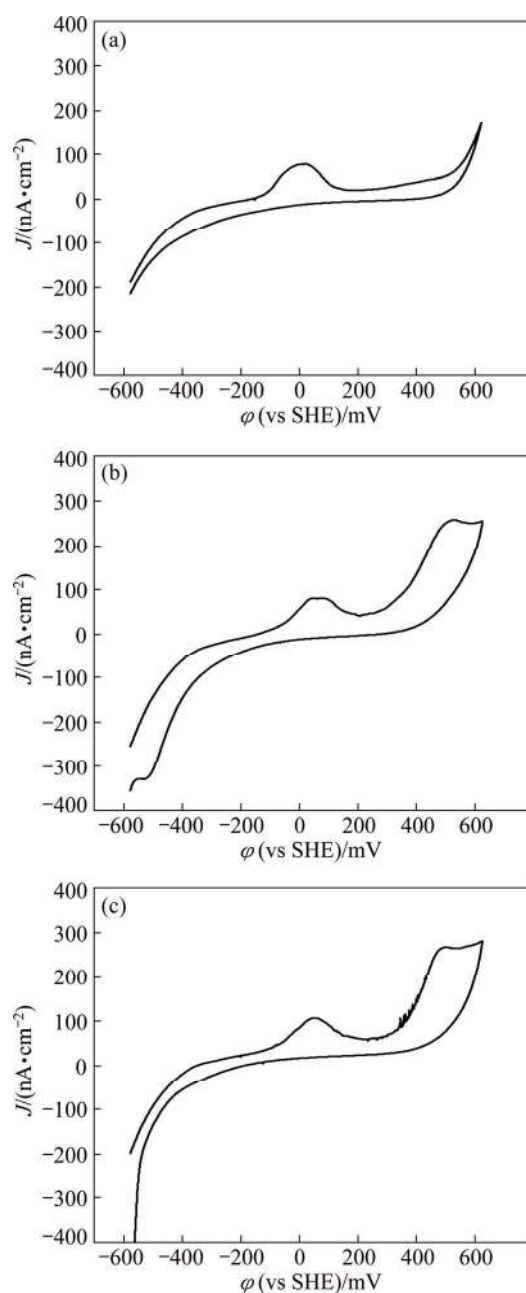
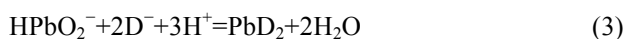
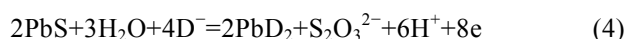


Fig. 3 Cyclic voltammogram curves of galena with DDTC as collector at scan rate of 20 mV/s, 25 °C, KNO_3 concentration of 0.1 mol/L and DDTC concentration of 1×10^{-4} mol/L under different pH values: (a) pH=6.82; (b) pH=12 adjusted by NaOH; (c) pH=12 adjusted by Ca(OH)₂

As positive scanning processes, anodic peaks of PbD_2 and galena are separated, PbD_2 can be produced according to the following reaction as oxidative product of galena is $\text{S}_2\text{O}_3^{2-}$.



The cyclic voltammogram curves of jamesonite under the same condition are presented in Fig. 4. It is shown in Fig. 4 that an anodic current peak emerges at potential of about 0 when DDTC is added. PbS occurs on

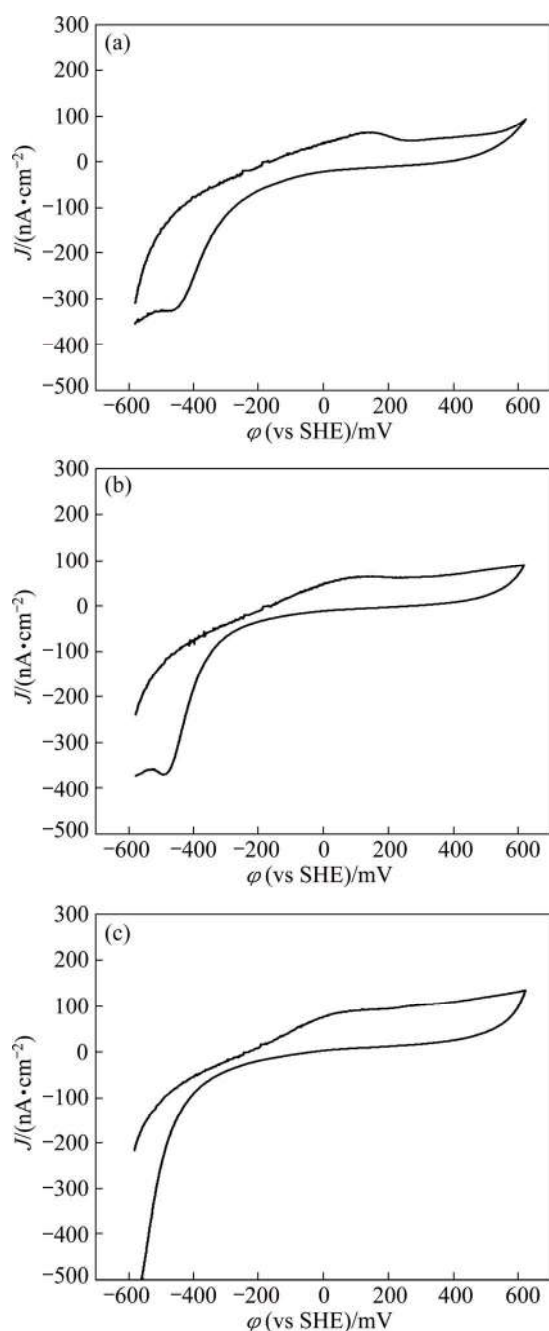
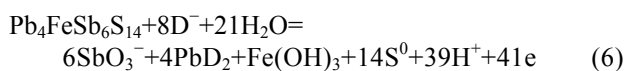
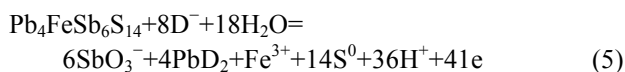


Fig. 4 Cyclic voltammogram curves of jamesonite with DDTC as collector at scan rate of 20 mV/s, 25 °C, KNO_3 concentration of 0.1 mol/L and DDTC concentration of 1×10^{-4} mol/L under different pH conditions: (a) pH=6.82; (b) pH=12 adjusted by NaOH; (c) pH=12 adjusted by $\text{Ca}(\text{OH})_2$

jamesonite surface under neutral and highly alkaline conditions. Here are the corresponding reactions:



After collector was added, the current densities of oxidation peak and cathodic reduction peak declined,

indicating that the inactivation occurred. And Fe^{3+} and $\text{Fe}(\text{OH})_3$ were produced according to Eqs. (5) and (6), respectively. Compared with the natural pH, high alkaline conditions have a sharper decline, which might result from the fact that the hydrophilic ferric hydroxide covered the surface of jamesonite electrode [3,12,20], thus hindering the collector to react with mineral particles.

3.3 Tafel curves

The Tafel curves and galvanic corrosion parameters of galena in electrolyte solution are presented in Fig. 5 and Table 1, with DDTC as collector and under natural pH condition, pH 12 fixed by NaOH and pH 12 fixed by lime, respectively. As can be seen from the figure, when DDTC is added, corrosion current of galena declined drastically at the same degree under different conditions. This is due to the high alkaline system and the system of high alkaline calcium has little effect on the interaction between DDTC and galena. DDTC generated sodium diethyl dithiocarbamate which is hydrophobic, covering the surface of galena and inhibit its oxidation.

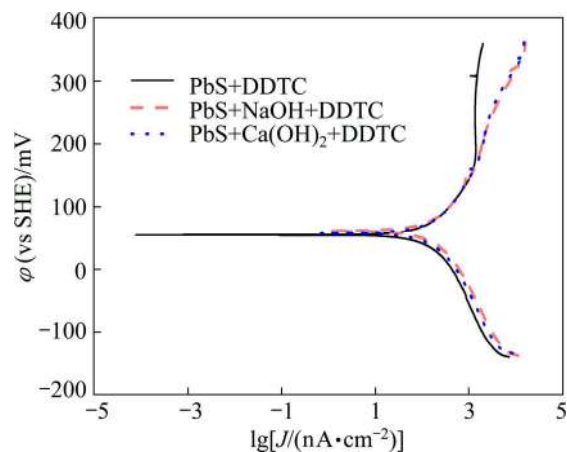


Fig. 5 Tafel curves of galena with DDTC as collector at scan rate of 20 mV/s, 25 °C, KNO_3 concentration of 0.1 mol/L and DDTC concentration of 1×10^{-4} mol/L under different pH systems

Table 1 Electrochemical corrosion parameters of galena under different pH systems with DDTC as collector

pH system	$\varphi_{\text{corr}}(\text{vs SHE})/\text{V}$	$J_{\text{corr}}/(\text{nA} \cdot \text{cm}^{-2})$
Nature	52.35	364
NaOH	60.93	392
$\text{Ca}(\text{OH})_2$	57.23	410

The Tafel curves and galvanic corrosion parameters of jamesonite in electrolyte solution are presented in Fig. 6 and Table 2, with DDTC as collector and under natural pH condition, pH 12 adjusted by NaOH and pH 12 adjusted by $\text{Ca}(\text{OH})_2$, respectively. Figure 6 shows

that under natural pH condition, corrosion potential of the system reduces from 67.81 to 21.63 mV. The corrosion current density decreases from 7.658 to 4.027 $\mu\text{A}/\text{cm}^2$, which means that DDTC is adsorbed on the surface of jamesonite. But changes of corrosion potential and corrosion current are less than those of galena, indicating that DDTC has stronger collecting capacity to galena than to jamesonite under the same condition.

At high pH value, with addition of the collector, there is no obvious change in the corrosion potential and corrosion current density, while they decline more slightly in high alkaline system than that in high alkaline calcium system. This may result from the adsorption and coverage of hydroxyl compounds and calcium compounds [3,12,16]. The interaction between DDTC and jamesonite is very weak at high pH value. This can be the foundation of separating galena and jamesonite with DDTC under high alkaline calcium system.

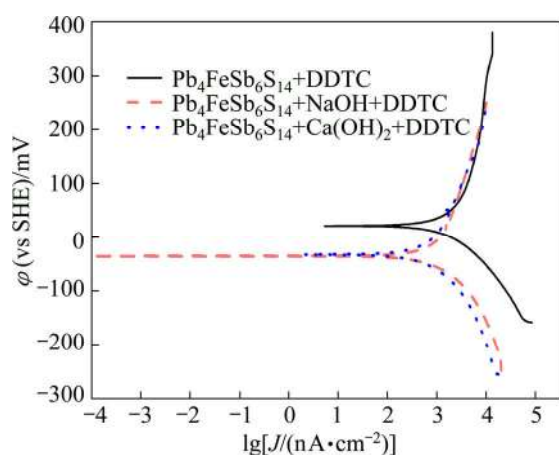


Fig. 6 Tafel curves of jamesonite with DDTC as collector at scan rate of 20 mV/s, 25 °C, KNO_3 concentration of 0.1 mol/L and DDTC concentration of 1×10^{-4} mol/L under different pH systems

Table 2 Electrochemical corrosion parameters of jamesonite under different pH systems with DDTC as collector

Mineral	$\varphi_{\text{corr}}(\text{vs SHE})/\text{mV}$	$J_{\text{corr}}/(\mu\text{A}\cdot\text{cm}^{-2})$
Jamesonite	67.81	7.658
Jamesonite+DDTC	21.63	4.027
Jamesonite+NaOH	-29.88	2.102
Jamesonite+NaOH+DDTC	-34.76	1.985
Jamesonite+ $\text{Ca}(\text{OH})_2$	-30.73	1.541
Jamesonite+ $\text{Ca}(\text{OH})_2$ +DDTC	-32.156	1.413

4 Conclusions

1) Pulp pH has a significant influence on the flotation of galena and jamesonite. In high alkaline

condition adjusted by lime, better separation between galena and jamesonite is obtained than that in high alkaline condition adjusted by NaOH.

2) Through potential scan of cyclic voltammograms and analysis of Tafel tests, it can be concluded that electrochemical reactions play an important role in the interaction of DDTC with galena and jamesonite. High pH value has little effect on electrochemical property on galena surface and the interaction between galena and DDTC. As to jamesonite, due to self-oxidation and specific adsorption of OH^- and CaOH^+ , non-electroactive hydroxyl compound and low-electrical-conductive calcium compounds are generated on the jamesonite surface, hindering the transfer of the electrons on the surface of the electrode. Thus, the adsorption of DDTC on jamesonite surface is difficult, leading to the drastic decline of floatability of jamesonite.

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方铅矿与脆硫锑铅矿在高碱体系中的浮选电化学行为

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摘要: 为有效分离方铅矿和脆硫锑铅矿并提高其在混合浮选中的回收率, 研究两者与乙硫氮捕收剂(DDTC)的作用机理。通过单矿物浮选实验研究矿浆 pH 值对两者浮选行为的影响。通过循环伏安法和塔菲尔曲线测试研究两者与乙硫氮作用的电化学性质。浮选实验结果表明, 在高碱体系中脆硫锑铅矿被石灰强烈抑制。循环伏安曲线和塔菲尔曲线表明, 乙硫氮与方铅矿和脆硫锑铅矿的作用是电化学过程。高碱体系对方铅矿与乙硫氮的作用影响不大, 但是对脆硫锑铅矿影响很大, 这是其自身氧化以及 OH^- 和 CaOH^+ 等离子的特性吸附, 导致非电活性的羟基化合物和低导电性的钙系化合物附着在其表面, 阻碍电子在电极表面的传递, 从而使脆硫锑铅矿的可浮性降低。
关键词: 方铅矿; 脆硫锑铅矿; 浮选; 电化学行为; 循环伏安法; 塔菲尔测试

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