Effects of dispersants on preparing coal pitch water slurry

H H Chang¹, L F Liu¹, X Li¹, Y W Li & W L Wei*¹,²
¹College of Chemistry and Chemical Engineering, Taiyuan University of Technology, Shanxi Taiyuan, 030024, China
²State Key Laboratory of Coal Conversion, Shanxi Taiyuan, 030001, China
E-mail: weiwcnlong@tyut.edu.cn

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The coal pitch water slurry (CPWS) has been prepared with solutions of dispersants and medium temperature coal tar pitch powder corresponded with “bipeak trifurcated distribution” made by cryogenic grinding technology. The influences of HDBAC and Octadearyl dimethyl ammonium chloride on slurry ability, rheological behavior and stability of the CPWS have been investigated. Moreover, wetting, adsorption and the Zeta potential of aqueous solutions of dispersants on coal tar pitch's surface have also been discussed. The results show that HDBAC and STAC are both suitable to prepare the CPWS, and HDBAC is the better one. Apparent viscosity of the CPWS increases with the growing of slurry concentration when surfactant dosage remain unchanged, and the slurry concentration of CPWS prepared by HDBAC and STAC can reach 70% at most. The apparent viscosity declines when shear rate grows, so apparently, the CPWS is a pseudo plastic liquid and has a better rheological behavior. The stability becomes weaker with the passage of time. The adsorption of dispersants and Zeta potential on coal pitch's surface increase with the growing of solution concentration. The contact angle of solution on coal tar pitch surface declines when dispersants added, which is helpful to build a stable diverse system.

Keywords: Coal pitch, Coal pitch powder, Coal pitch water slurry, Dispersant

The coal play an important role in improving process of human beings. Its storage is declining down, so study on coal gasification, liquefaction and coal bed gas is becoming a hot topic¹⁻³. And investigation in properties of coal seam provide a guarantee of the safety of the coal mining⁴⁻⁵. The coal tar pitch is distillation residue of coal tar, whose yield is 50%~60%, and the using of which is crucial⁶⁻⁷. Its utilization has already come to binder⁸, impregnation⁹, needle coke¹⁰, carbon fiber¹¹, nanometer spherical carbon¹² paving and building materials¹³. However, new ways are pressing to be found to make more use of it.

The coal water slurry and petroleum asphalt were borrowed to come forward the conception of coal tar pitch water slurry (CPWS) by our research team¹⁴. A large amount of experiments have been done to reveal that surfactants play a very important role in preparing the CPWS¹⁵⁻¹⁷. Based on previous studies, many more dispersants were selected to prepare the CPWS, HDBAC and STAC were chosen to investigate its slurry ability, rheological behaviour and stability. In addition, the wetting behaviour, adsorption of dispersants and Zeta electric potential on coal pitch's surface were also investigated.

Experimental Section

Raw materials and reagents

The medium temperature coal tar pitch, whose soft point was 94.5°C measured by ring and ball method, was prepared by cryogenic grinding method, whose particle distribution grading can be seen in Fig. 1. It's shown that the particle size of coal pitch powder is lower than 400 µm, and corresponded with “bipeak trifurcated distribution”.

The reagents used in this experiment, including sodium anthraquinone-2-sulfonic acid sodium, sodium 1-naphthalenesulfonate, sodium dodecyl benzene sulfonate, sodium dodecyl sulfate, hexadecyl trimethyl ammonium chloride, octadecyl trimethyl ammonium chloride, dodecyl trimethyl ammonium chloride, octyl trimethyl ammonium chloride, tetrabutyl ammonium bromide, Benzyldimethylhexadecylammonium chloride, phenyl

Fig. 1—Granularity distributing of coal tar pitch powder
trimethyl ammonium chloride and tetramethyl ammonium chloride, were all analytical reagents.

The main instruments in this research were THZ-C-1 desktop constant speed oscillator, NXS-4C coal water slurry viscometer, TU-1901 UV spectrophotometer, HARKE-SPCA contact angle measuring instrument and JS94H Micro electrophoresis apparatus.

The preparation and investigation of CPWS

The dispersants were added into distilled water, stirred at a speed of 3000 r/min. The coal pitch powder was then added slowly, with continuous stirring for 20 min until the slurry became well-distributed to achieve the CPWS. The NXS-4C rotational viscometer was used to measure apparent viscosity of the slurry, which was never more than 1200 mPa•s. The rheological behavior was examined by apparent viscosity changed with the shear rate. The stability was decided by the method of "rod-insertion". The adsorption of dispersants and the Zeta potential on coal pitch surface were measured as reported. The coal tar pitch powder was made into slice with the diameter of 1cm. And then the contact angle of solution on coal tar pitch was investigated by HARKE-SPCA contact angle measuring instrument. What is said above was used to measure the wettability of dispersants on the coal pitch surface.

Results and Discussion

The influences of various dispersants on the preparation and properties of CPWS

The influence of different dispersants on the preparation of CPWS was studied when the dispersant concentration were 0.4% (a percentage by mass relative to the coal pitch powder) and slurry concentration was 67%. The results show some dispersants could not meet the requirment to prepare the CPWS, including sodium anthraquinone-2-sulfonic acid sodium, sodium 1-naphthalenesulfonate, sodium dodecyl benzene sulfonate, sodium dodecyl sulfate, hexadecyl trimethyl ammonium chloride, dodecyl trimethyl ammonium chloride, octyl trimethyl ammonium chloride and tetrabutyl ammonium bromide, etc, because of the poor wettability and too much foam. However, octadecyl trimethyl ammonium chloride (STAC) and Benzyl hexadecyl dimethyl ammonium chloride (HDBAC) could be used to prepare slurry that has better rheological behavior and stability. Therefore, more experiments were done to investigate the influences of dispersants, HDBAC and STAC, on the preparation and properties of CPWS.

Apparent viscosity of CPWS

Slurries were prepared by STAC and HDBAC to survey the relationship between dispersants and apparent viscosity, the results are shown in Fig. 2.

It can be seen from the Fig. 2 that when dispersants’ concentrations remain the same, apparent viscosity of CPWS increases obviously with the growing of slurry concentration, then the increasing trend slows down with time goes by and remains steady at last. The slurry concentration could all reach 70% at most with HDBAC and STAC, which indicates that STAC and HDBAC were both excellent dispersants of CPWS. The apparent viscosity of slurry made from HDBAC is lower than that of STAC, indicating that the former one is better.

Rheological behaviour of CPWS

The apparent viscosity of CPWS made from HDBAC decreases with the increasing of shear rate, indicating that it is a pseudo-plastic liquid as shown in Fig. 3. When shear rate remains unchanged, apparent viscosity increases with the growing of slurry concentration. The CPWS with concentration of 67% has the best rheological behaviour.

It can be seen from the Fig. 4 that with the increasing of shear rate, apparent viscosity of CPWS prepared by STAC declines, which dedicating that it is a pseudo-plastic liquid. Moreover, apparent viscosity increases with the growing of slurry concentration at the same shear rate. The dispersant’s concentration has nothing to do with rheological behaviour of the CPWS. The CPWS with concentration of 69% has the best rheological behaviour.

As seen from all above, the CPWS made from HDBAC and STAC are both pseudo-plastic liquid, and the rheological behaviour of HDBAC is better than that of STAC.

Stability of CPWS

The stability of CPWS made from STAC and HDBAC was evaluated by "rod-insertion" method, putting a rod into the test tube full of CPWS to see if there is precipitate there. The data are shown in Table 1 and Table 2.
The stability of CPWS made from HDBAC and STAC strengthens at first and then dies down with the growing of surfactants dosage and slurry concentration. The slurries could be stable for 30 days. And the stability of CPWS made from HDBAC is better than that of STAC.

Adsorption of dispersants on coal tar pitch’s surface

The adsorption amount of dispersants grows with the increasing of concentration as shown in Fig. 5. The adsorption amount of HDBAC increases rapidly when the concentration of dispersant is greater than 600 mg/L. The adsorption amount of STAC changes

(a, b, c, d, e, f—the dispersant concentration are respectively 0.2%, 0.4%, 0.6%, 0.8%, 1.0% and 1.2%)

Fig. 2 — The effect of slurry concentration on slurry ability of coal tar pitch
slowly all the time. So the adsorption of HDBAC on the surface of coal pitch was stronger than that of STAC, which leads to better rheological behaviour and stability.

**Zeta potential of coal pitch’s surface**
The coal pitch powder was added into dispersants' solutions with different concentrations of HDBAC and STAC. The Zeta potential of coal pitch’s surface was measured by Micro electrophoresis apparatus when the system reaching absorption equilibrium. The results are presented in Fig. 6.

It can be seen from Fig. 6 that the Zeta potential grow with the increasing of dispersant’s concentration. The reason could be that as the dosages
of dispersants increase, more and more dispersants are adsorbed on the coal pitch's surface due to the electrostatic attraction. When the adsorption of dispersants on coal tar pitch's surface is saturated, the Zeta potential reaches maximum. Continue adding dispersants, multilayer adsorption would occur on the coal pitch's surface, and at the same time, the Zeta potential would decline slightly. What is said above is corresponded to the investigation of Zeta potential of CWS.

Fig. 4 — The effect of STAC on rheological behavior of CPWS
The wettability of dispersants' solutions, whose concentrations are 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2%, on the coal pitch's surface was decided by contact angle, as shown in Table 3.

It can be seen in Table 3 that all the contact angles are between 0°~40°, which indicates that both the two kinds of dispersants' solutions have a better wettability on coal pitch's surface. The contact angle of pure water on the coal pitch's surface was 100.4°, which demonstrates that the wettability of pure water is weak. Therefore, dispersants can contribute to the wettability, which is helpful to prepare stable diverse system. The contact angle declines with the growing of HDBAC's concentration, and all below 30°. While as STAC's concentration increases, the contact angle grows at first and then decreases and all below 40°. In conclusion, the contact angles of solutions prepared by HDBAC are smaller than that of STAC, in other words, the wettability of HDBAC is better than that of the other one.

### Table 3—Contact angle of dispersant solution on the coal pitch surface

<table>
<thead>
<tr>
<th>Contact angle (°)</th>
<th>HDBAC</th>
<th>STAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersant (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>16.6</td>
<td>31.3</td>
</tr>
<tr>
<td>0.4</td>
<td>10.4</td>
<td>32.9</td>
</tr>
<tr>
<td>0.6</td>
<td>16.2</td>
<td>33.6</td>
</tr>
<tr>
<td>0.8</td>
<td>5.8</td>
<td>37.9</td>
</tr>
<tr>
<td>1.0</td>
<td>13.9</td>
<td>29.0</td>
</tr>
<tr>
<td>1.2</td>
<td>5.4</td>
<td>28.2</td>
</tr>
</tbody>
</table>

### Wettability on the coal pitch's surface

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Conclusion

The apparent viscosity of CPWS increases with the growing of slurry concentration when surfactants dosage remains the same, and the concentrations of CPWS could reach 70% at most. The apparent viscosity of CPWS prepared by HDBAC and STAC declines with the growing of shear rate, that is to say, the CPWS is a pseudo plastic liquid. When shear rate stays unchanged, apparent viscosity increases with the growing of slurry concentration. The dispersant’s concentration has little effect on rheological behaviour of CPWS. The stability of CPWS grows at first and then decreases with the increasing of slurry concentration and surfactants dosage. The slurries prepared by STAC can be stable for 40 days, while that of HDBAC can be 44 days.

The adsorption amount and Zeta potential of dispersants on coal pitch surface grows with the increasing of dispersants' concentration. The Zeta potential reaches maximum when dispersants' concentration is 1200 mg/L, and then decreases slightly when dispersant’s concentration continues growing. The contact angle between water and coal pitch surface declines when HDBAC and STAC added in, which improving the wettability.

The results of research in slurry ability, rheological behaviour and stability of CPWS show that HDBAC is better than STAC in preparing CPWS, which is corresponded with the investigation of adsorption amount and Zeta potential. And furthermore, the study on wettability of coal pitch surface is also agree with that.

Acknowledgement

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References