Applied Mechanics and Materials *Online: 2014-01-08*
ISSN: 1662-7482, Vols. 488-489, pp 316-321
doi:10.4028/www.scientific.net/AMM.488-489.316

Study on Properties of the Blends with Direct Coal Liquefaction Residue and Asphalt

Ji Jie Zhao Yong-shang Xu Shi-fa

Beijing University of Civil Engineering and Architecture, Beijing, P.R of China,100044

E-mail:jijie@bucea.edu.cn

Keywords: DCLR, asphalt, blends, furfural extract oil, properties

Abstract. This paper studies the properties of the blends composed of DCLR (direct coal liquefaction residue) and asphalt using two different processing methods, compares the regulation that the DCLR additive content and processing method take influence on the high-temperature properties, low-temperature properties and durability of the blends. It is found that the DCLR can improve the high-temperature properties of asphalt but degrade its low-temperature properties. The properties of blends composed of DCLR, asphalt and furfural extract oil are tested and analyzed by adding a certain amount of furfural extract oil into it, which shows that adding DCLR can improve the high-temperature properties of asphalt and reduce its low-temperature properties but can hardly cause any impact on the properties of the blends. In addition, the processing method has a direct influence on the properties of blends.

1.Introduction

China is a country with rich coal and gas but little petroleum. At present, the explored coal reserves reach 1.3983 trillion tons, ranking the second place in the world. However, petroleum resources are relatively rare in China. In 2012, the gap of supply and demand for petroleum in China is nearly 300 million tons which results in that China's dependence on imported petroleum climbs up to 60%. In order to relieve the shortage of petroleum resources in China, it has been an important energy strategy trend to produce petroleum from coal. Our demand for liquid fuel can be basically met by means of coal liquefaction. The coal liquefaction can be classified by direct liquefaction and indirect liquefaction according to the processing method [1] [2] [3], among which the direct coal liquefaction for petroleum brings in a higher conversion rate and lower cost. Therefore, it witnessed a quick development.

In the direct coal liquefaction process, apart from liquid fuels such as gasoline and diesel[4][5], the main byproduct liquefied residues are also produced which accounts for 30% of total feed coal. In fact, the direct coal liquefaction residue (DCLR) includes 30~50% of heavy oil and asphaltene, which is similar with Trinidad lake asphalt (TLA, a natural modifier to improve the asphalt properties) in composition and some physical properties. Among non-polymer additives, with a good modification property, TLA has been widely applied all over the world. Many important projects in China also use TLA, e.g. Jiang-Yin Bride, western runway of Beijing Capital International Airport and Zi-Yang Section of Chengdu-Chongqing Expressway. With the construction of expressways in China and improvement of common highway, the demand for TLA also increases. However, the application of TLA is restricted since the TLA source is limited and import price is high.

DCLR is a substance most similar with TLA in properties. Hence, the study on new technology that the blends with DCLR and asphalt are secondarily developed to an asphalt modifier which is used for replacing the TLA to improve the asphalt properties has very important scientific significance and application value. On the one hand, DCLR, as an asphalt modifier, can significantly improve the asphalt properties, reduce the price of modified asphalt (DCLR price is only equivalent to a quarter of TLA) and promote the development of asphalt industry of China; on the other hand, the use of asphalt modified by DCLR is of positive significance in environmental protection, reasonable use of limited resources and increase of DCLR utilization.

2. Properties of raw materials

2.1 DCLR

DCLR used in this paper is from the direct coal liquefaction residue manufactured by Mongolia Branch of CHINA SHENHUA COAL TO LIQUID AND CHEMICAL CO., LTD. and its properties are as shown in Table 1.

Table 1 Properties of DCLR

Items	Density	Softening point(℃)	25℃ penetration (0.1mm)
Test results	1.23	170	2

2.2 Asphalt

In this paper, 70# asphalt of SHANDONG DONGMING PETROCHEM GROUP is used, with its properties is shown in Table 2. 70# asphalt meets current requirements of *Technical Specification for Construction of Highway Asphalt Pavements (JTG F40-2004).*

Table 2 Properties of 70# Asphalt

Items	Unit	Requirements	70# Asphalt
25℃ penetration	dmm	60~80	64
Softening point	℃	≧46	50.9
10℃ ductility	cm	≧20	24
60℃ viscosity	Pa·s	≧180	191.8
Residue after RTFOT			
Loss of mass	%	±0.8%	+0.3%
Residual penetration ratio	%	≧61	64
Residual ductility(10℃)	cm	≧6	6.5

3. Processing method for blends composed of DCLR and asphalt

DCLR used in this paper is powder and blends with asphalt using two different processing methods [6] [7] [8]. The flow is as shown in Figure 1~ 2.

Figure 1 shows the processing method of DCLR powder blending with asphalt. The main procedures are as follows: firstly heat the asphalt, and then add different amounts of DCLR into melting asphalt directly. In order to ensure that DCLR is fully blended with asphalt, the blends composed of DCLR and asphalt is sheared with a shear apparatus for 1 hour at low speed under the temperature of 160℃.

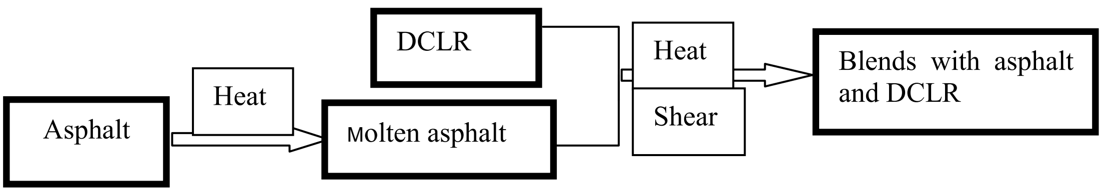

Figure 1 Processing Method I

Figure 2 shows the second processing method of power DCLR with asphalt. The main procedures are as follows: heat the asphalt and DCLR respectively to melting status, and then blend molten DCLR and asphalt in a certain proportion. In order to ensure that DCLR is fully blended with asphalt, the blends composed of DCLR and asphalt is sheared with a shear apparatus for 1 hour at low speed under the temperature of 160℃.

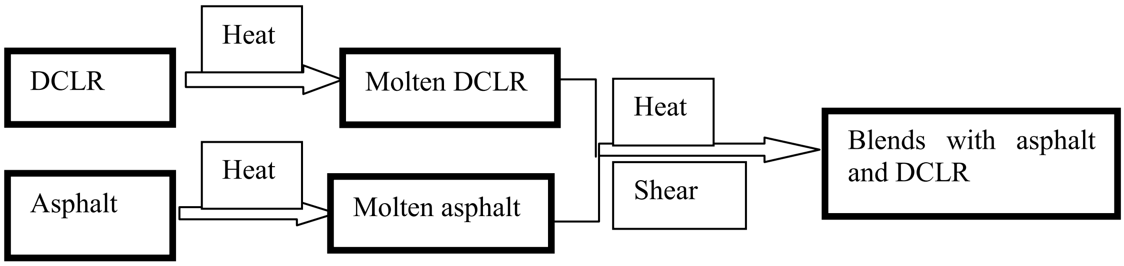

Figure 2 Processing Method II

4. Test result and analysis

4.1 Properties of the blends

In this paper, according to *Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering* (JTG E20-2011), properties test is conducted for blends composed of DCLR, asphalt and FEO (furfural extract oil) produced by two different processing methods. Properties regulations of blends are analyzed. Table 3 shows different addition quantity of DCLR and FEO and the test results of blends are shown in Table 4~5.

Table 3 Different Addition Quantity of DCLR and FEO

DCLR Content	3%	5%	10%	15%	20%
FEO Content	0%	0%	1%	2%	4%

Table 4 Properties of Blends (According to the Processing Method I)

Items	Unit	3%DCLR	5%DCLR	10%DCLR+ 1%FEO	15%DCLR +2%FEO	20%DCLR +4%FEO
25°C penetration	dmm	59	53	41	38	30
Softening point	°C	49.7	52.4	54.2	57.3	59.2
10°C ductility	cm	16.5	13.6	6.6	3.3	1.8
135°C viscosity	Pa·s	0.36	0.38	0.38	0.49	0.49
Residue after RTFOT						
Loss of mass	%	0.05	0.02	0.01	0.07	0.03
Residual penetration ratio	%	58	62	59	61	67
Residual ductility (10°C)	cm	4.1	3.2	2.1	1.2	0.8

Table 5 Properties of Blends (According to the Processing Method II)

Items	Unit	3%DCLR	5%DCLR	10%DCLR+ 1%FEO	15%DCLR +2%FEO	20%DCLR +4%FEO
25°C penetration	dmm	54	47	34	28	27
Softening point	°C	50.7	52.5	55.2	59	59.2
10°C ductility	cm	17.7	15.5	8.8	6.2	1.9
135°C viscosity	Pa·s	0.37	0.37	0.48	0.48	0.49
Residue after RTFOT						
Loss of mass	%	0.01	0.03	0.01	0.03	0.02
Residual penetration ratio	%	61	64	61	58	63
Residual ductility(10°C)	cm	5.4	3.5	3.2	1.1	1

From Table 4~5, it is shown that the addition of DCLR enhances high-temperature properties of asphalt but has a negative effect on its low-temperature properties. Comparatively speaking, the processing method has a certain effect on the properties of the blends.

4.2 Compare high-temperature properties of the blends
(1) Penetration
Figure 3 compares the penetration of the blends using two different processing methods.

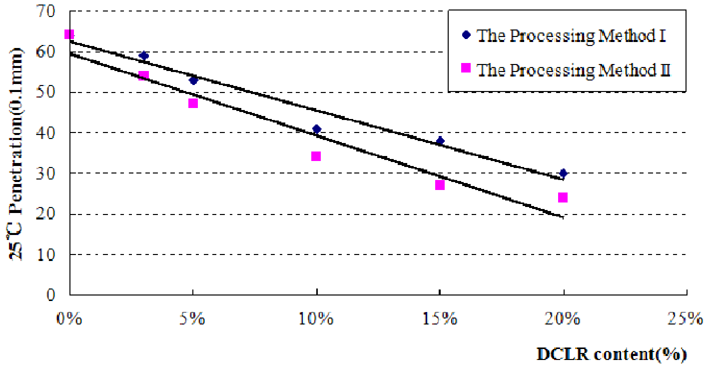

Figure 3 Penetration of Blends over DCLR Content

In Figure 3, it is shown that under two different processing methods, the penetration of the blends will decrease constantly with the increase of DCLR addition, basically presenting a linear variation. This means that adding DCLR will make asphalt hardened and enable its high-temperature properties to be improved. Enhancement of high-temperature properties of asphalt is more obvious with increase of DCLR addition. From Figure 3, it can be indicated that the addition of FEO can alleviate the decrease of penetration of the blends, which suggests the addition of FEO has a certain negative effect on high-temperature properties of the blends.

Figure 3 also shows that the processing method has a certain effect on the properties of the blends, and the impact on the high-temperature properties of the blends using processing method II is more obvious than processing method I.

(2) Softening point
Figure 4 compares the softening point of the blends using two different processing methods.

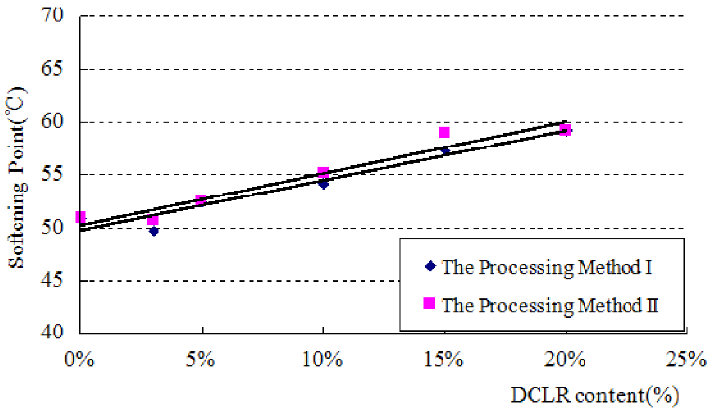

Figure 4 Softening Point of Blends over DCLR Content

From Figure 4, it is shown that softening point of the blends using two different processing methods rises with the increase of DCLR addition. Meanwhile, variations in softening point of the blends tend to be gentle with the addition of FEO, which indicates FEO has a certain adverse effect on high-temperature properties of the asphalt.

Figure 4 shows that processing method has great effect on softening point of the blends. The impact on the high-temperature properties of the blends using processing method II is more obvious than processing method I, which keeps with the changes of its penetration.

3.3 Compare low-temperature properties of the blends
Figure 5 compares the ductility of the blends using two different processing methods.

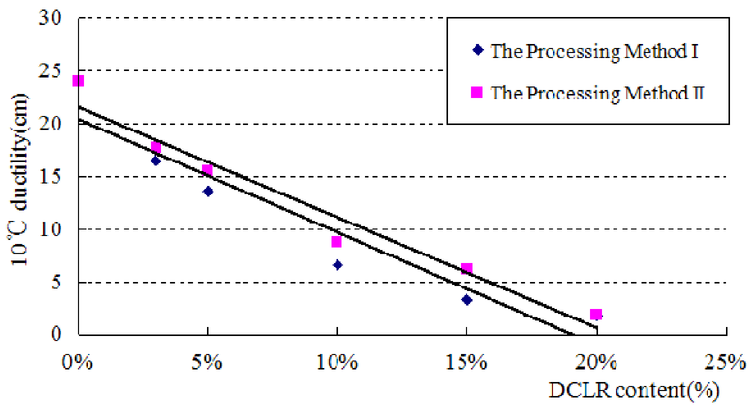

Figure 5 The Ductility of Blends over DCLR Content

From Figure 5, it is shown that the ductility of the blends produced by two different processing methods decreases with the increase of the DCLR addition. It is in linear variation basically. The ductility of the blends can not be improved after furfural extract oil is added.

Figure 5 also shows that processing method has great effect on the ductility of the blends. The negative impact on the ductility of the blends using processing method II is less than processing method I.

4.4 Compare durability of blends

Figure 6 compares the durability of the blends using two different processing methods.

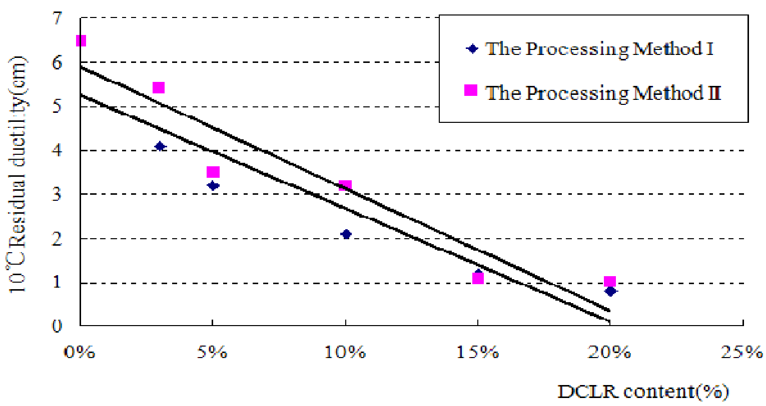

Figure 6 Residual Ductility of Blends over DCLR Content

From Figure 6, it is shown that the residual ductility of the blends decreases with the increase of the DCLR addition, basically presenting a linear variation. The residual ductility of the blends can not be well improved after adding FEO.

Figure 6 also shows that processing method has great effect on the ductility of the blends. The impact on the residual ductility of the blends using processing method II is less than processing method I.

5. Conclusions

Through a series of tests, the following conclusions are obtained:

(1) High-temperature properties of blends increase gradually with the increase of DCLR content but its low-temperature properties decrease gradually.

(2) The processing method has a certain effect on the properties of blends. Comparatively speaking, the properties of the blends produced by processing method II are much better.

(3) The addition of FEO can bring in a certain effect on the properties of blends though the effect is not dramatic.

6. Acknowledgment

The paper was supported by the Importation and Development of High-Caliber Talents Project of Beijing Municipal Institutions (Grant No.PXM2013-014210-000165). The authors wish to express their gratitude to Mr. Jinqi GAO for his assistance in some of the preliminary laboratory work.

References

[1] Shu Ge-ping, Shi Shi-dong,Li Ke-jian: Coal liquefaction technology. Coal Industry Communication.Beijing,1991
[2] Cao Zeng-yan:Clean coal technology in China. China Goods Communication. Beijing,1998
[3] Xie Ke-cang:Coal structure and reactivity .Science Communication,Beijing,2002
[4] Gao Jin-sheng,Zhang De-xiang:Coal liquefaction technology. Chemical Industry Communication. Beijing,2005
[5] Robin AM.Annual Report FE-2247-7:Gasification of residual materia1s from coal 1iquefaetion.Fossil Energy:Energy Researeh and Development Administration.1977
[6] Zhu Wei-ping, Research on DCLR modified asphalt. Shenhua Science,2009, 7(6):68-85
[7] Duan wen-qing. Research on performance and mix design of TLA modified asphalt.Journal of XiangTan Normal College，2006,28(2),105-108.
[8] Wang Zhai-xia,Yang Jian-li,Liu Zhen-yun. The evaluation on DCLR modified asphalt. Journal of fuel chemistry，2007, 35(1):109-112