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ORIENTAL JOURNAL OF CHEMISTRY
An International Open Free Access, Peer Reviewed Research Journal

www.orientjchem.org

ISSN: 0970-020 X
CODEN: OJCHEG
2015, Vol. 31, No. (4):
Pg. 1853-1857

Modification Bituminous Binders Petroleum Resin (Based on C9 Fraction)

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http://dx.doi.org/10.13005/ojc/310401

(Received: September 05, 2015; Accepted: October 14, 2015)

ABSTRACT

The goal of the present study is to measure the basic parameters of a bituminous binder obtained by modification of the BND 60/90 binder with petroleum resin, for both dynamic and static modification modes.

Key words: Bitumen, Binder, Petroleum Resin, Road pavement, Impregnating composition, Modifying agent.

INTRODUCTION

Asphaltic concrete is recognized as the most convenient roadway surfacing worldwide. The demand for high-quality durable roadway surfacing has been ever increasing, caused by rapid degradation of the upper layers of the surface which leads to the failure of its waterproofing properties followed by decreased crack resistance, washboard formation and other destructive factors.

Such climatic factors as humidity, thermal gradients, ultraviolet radiation and atmospheric oxygen have a negative influence on the properties of asphaltic concrete. The traffic load from heavy vehicles contribute to the decline of the technical parameters of asphaltic concrete, in particular the shear resistance and the surface roughness.

Technology of roadway protection using impregnation compositions on the basis of bitumen binders modified with polymeric materials is a promising way to improve the quality and lifetime of asphalt concrete.

Treatment of the surface of asphalt concrete coatings with impregnation compositions allows to slow down (or halt) the already started destructive processes[1].

A composition which when applied onto the surface of asphalt concrete could provide rapid

drying (30 – 50 min) while retaining the parameters necessary for protection against the unfavorable factors is described in paper[2].

Modifying polymeric additives are known to change the physical-mechanical properties and the structure of the binder thus acting as a plasticizer in the dispersion environment. At the same time the bitumen-polymer system components undergo chemical reactions resulting in the formation of a single spatial structure[3].

The composition described in[2] makes use of a petroleum resin (PR) as a bitumen binder modifier.

The petroleum resins produced from C_8 – C_{10} fractions of pyrolysis of raw hydrocarbon material possess relatively high glass transition temperatures have a high content of double bonds (defined by the structure of the resins) and thus are able to form coatings in acceptable times without the accumulation of cross-linked polymer[4].

The petroleum resins can successfully be applied as an effective structure forming additive to low viscity bitumen and petroleum residues. The possibility and usefullness of the use of PR for these purposes were studied for «Pyroplast» petroleum resin[5]. High-viscosity roadway bitumen are quite in a short supply, which causes the necessity of the search for new effective means of application of composite binders produced from low-viscosity bitumen and petroleum residues.

Application of petroleum resins as modifiers for bitumen is described in papers[6-10].

The PR are products of raw petroleum processing, same as the bitumen, which provides their good compatibility. Dark petroleum resins such as «Pyroplast-2» are characterized by irregular spatial structure and possess high thermal stability. Introduction of PR into low-viscosity bitumen and petroleum residues results in the formation of binders a with spatial structure which is increases the viscosity of the material and its cohesive strength[11].

The goal of the present study was to evaluate the key parameters of bituminous binders produced from the BND 60/90 binder by modification with petroleum resin in dynamic mode and statistical mode of modification.

MATERIAL AND METHODS

Commercially available bitumen of the BND 60/90 grade by «Lukoil» and «Slavneft-YANOS» were used. The material properties are presented in table 1.

Three key parameters are generally used in industrial practice for the estimation of bitumen properties: the depth of penetration of a needle (penetration), temperature of softening measured by the method «of a ring and ball» (RB), extensibility (ductility)[12].

For the modification of bituminous binder the petroleum resin «Sibplast» (the closest analogue of resin «Pyroplast-2») at the mass concentration of 15% masses used.

The petroleum resin «Sibplast» is a solid from yellow to brown color in pieces with the softening temperature of 80 – 130 °C. It is a product of thermal polymerization of C_9 – C_{12} (boiling at 120 – 210 °C) raw hydrocarbon pyrolysis conducted at of 240 – 250 °C and a pressure of up to 1.0 MPa.

Course of the experiment: The bitumen was softened and placed into a steel vessel equipped with a mechanical stirrer, thermometer, and a hot plate. The speed of the stirrer was set to 200 rpm. The stirred bitumen was heated to the temperature of 160 °C, then the PR (15 mass %) was introduced and the temperature raised to 180 °C. Then 100 g portions of the mixture were taken to five steel vessels which were put into a thermostatted air oven for the study of the three key parameters of the bitumen in a static modification mode, extensibility, penetration at 25°C and softening temperature by the RB method. The thermostat was set to 180 °C. Every 30 min one vessel was removed from the oven for the conduction of tests using the standard procedures. The total thermostating time was 150 min.

For the dynamic mode of study of the

bitumen parameters the material was placed into a steel vessel equipped with a mechanical stirrer, thermometer, and a hot plate. The speed of the stirrer was 200 rpm. The bitumen was heated with stirring to the temperature of 160 °C, then the PR was introduced (15 mass %) and the temperature raised up to 180 °C (measured inside the vessel). The reaction mass was heated further at 180 °C, while test samples (100 g each) were taken every 30 min. The total modification time was 150 min.

The sample testing was conducted according to standard procedures (GOST 11501-78; 32054-2013; 11505-75).

RESULT AND DISCUSSION

The experimental values of the key parameters of the modified bitumen are presented in tables and respectively.

Table 1: Properties of the bitumen makes of the BND 60/90 grade

S. No	Unit	BND 60/90 «Lukoil» bitumen	BND 60/90 «Slavneft-YaNOS» bitumen	Requirements for BND 60/90 bitumen (GOST 22245-90)
1	Penetration:			
	at 25°C, 0,1 mm	62	75	61-90
	at 0°C, 0,1 mm	21	22	≥ 20
2	Softening temperature, °C	53	51	≥47
3	Change the softening temperature after heating, °c	5	5	≥5
4	Intervale of plasticity:			
	at 25 °C, sm	72	80	≥55
	at 0 °C, sm	3,6	3,8	≥3,5
5	Penetration index	+0,3	+0,3	from – 1,0 to +1,0
6	Fraass breaking point, °C	–15	–15	≥–15

Table 2 Values of the penetration parameter for the modificaton of the BND 60/90 grade bitumen produced by «Lukoil» and «Slavneft-YANOS» with 15% of the «Sibplast PR»

Modification time (min)	Modification BND 60/90 «Lukoil» bitumen		Modification BND 60/90 «Slavneft-YaNOS» bitumen	
	Penetration at 25 °C, 0,1 mm			
	Dynamic mode (mixing 200 rpm, 180 °C)	Static mode (temperature control 180 °C)	Dynamic mode (mixing 200 rpm, 180 °C)	Static mode (temperature control180 °C)
0 (immediately after the mixing of bitumen and PR and adjust the mixture to 180 ° C)	51	51	63	63
30	46	46	59	60
60	45	45	56	60
90	40	45	52	56
120	39	43	48	54
150	33	43	42	54

Table 3: Values of softening temperature for the modificaton of the BND 60/90 grade bitumen produced by "Lukoil" and "Slavneft-YANOS" with 15% of the "Sibplast PR"

Modification time (min)	Modification BND 60/90 «Lukoil» bitumen		Modification BND 60/90 «Slavneft-YaNOS» bitumen	
	Penetration at 25 °C, 0,1 mm			
	Dynamic mode (mixing 200 rpm, 180 °C)	Static mode (temperature control 180 °C)	Dynamic mode (mixing 200 rpm, 180 °C)	Static mode (temperature control180 °C)
0 (immediately after the mixing of bitumen and PR and adjust the mixture to 180 ° C)	53	53	51	51
30	53	53	51	51
60	53	53	51	51
90	54	53	52	51
120	55	53	52	51
150	55	53	52	51

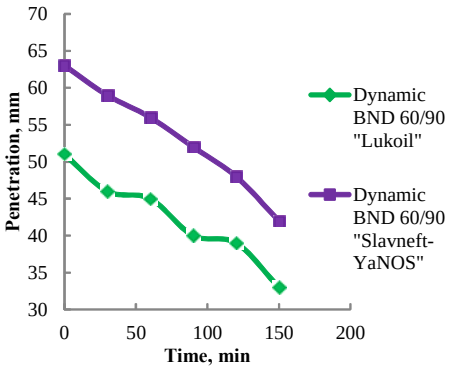

Fig. 1: The dependence of the penetration of the modification time for bitumen BND 60/90 «Lukoil» and 60/90 BND «Slavneft-YaNOS» in the dynamic mode

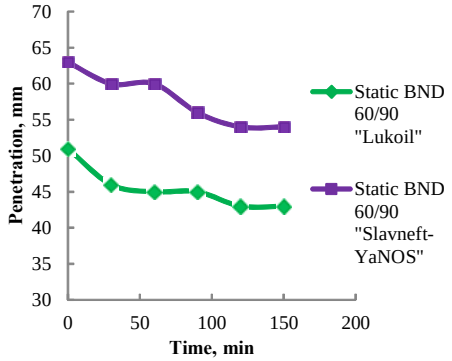

Fig. 2: The dependence of the penetration of the modification time for bitumen BND 60/90 «Lukoil» and 60/90 BND «Slavneft-YaNOS» in the static mode

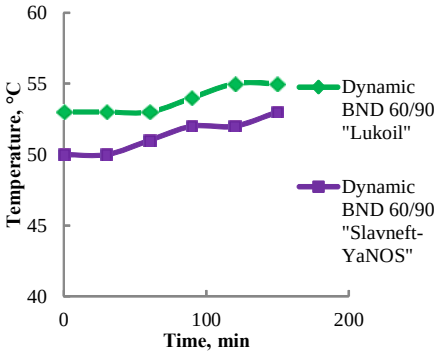

Fig. 3. The dependence of the temperature of softening «RB» from modification time for bitumen BND 60/90 «Lukoil» and 60/90 BND «Slavneft-YaNOS» in the dynamic mode

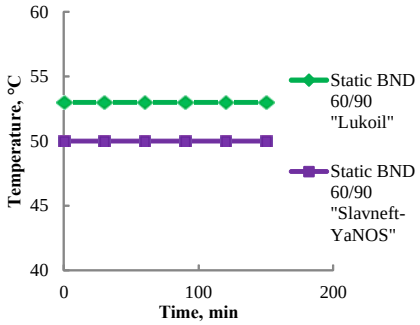

Fig. 4. The dependence of the temperature of softening «RB» from modification time for bitumen BND 60/90 «Lukoil» and 60/90 BND «Slavneft-YaNOS» in the static mode

Table 2 Values of the penetration parameter for the modificaton of the BND 60/90 grade bitumen produced by «Lukoil» and «Slavneft-YANOS» with 15% of the «Sibplast PR»

Ductility (25 °C) for all modified bitumen samples in both static and dynamic the modes was more than 150 cm.

The different influence of the time of modification of the penetration values for the two bitumen of the same grade in different modes (dynamic and static) are presented in Figures 1, 2 as well as the alterations of softening temperatures measured by the RB method (Figures 3, 4).

CONCLUSIONS

The following conclusions can be made from the results of the current study of modification of bitumen binders with a petroleum resin.

The temperature of softening measured by the RB method for bitumen of the same grade but having different initial values of softening temperature in the static modification mode remains constant, i.e. equal to the value of the unmodified binder;

The temperature of softening measured by the RB method for bitumen of the same grade but having different initial values of softening temperature is increased in the dynamic mode;

The values of penetration at 25 ºC of the modified bitumen binders is reduced almost in direct proportion to modification time for both modes;

The ductility of the bitumen binders at 25 °C was more than 150 cm for both modes.

By variation of the modification time and mode it is possible to produce modified bitumen binders with the desired technological parameters.

ACKNOWLEDGEMENTS

Applied researches are conducted with financial support of the state represented by the Ministry of Education and Science of Russia in under the Subsidy Grant Agreement ¹.14.579.21.0025 of June 5, 2014. (Unique Identifier for Applied Scientific Researches (project) RFMEFI57914X0025).

REFERENCES

1. Chigorina E. A., Razinov A. L., Retivov V. M. *Biosci., Biotechnol. Res. Asia* **2014***, 11,* 1679-1683.
2. Sandu R. A., Glushko A. N., Bulatitckiy K. K., Jdanovich O. A., Pozdnyaeva L. V., RF Patent No. 2516605, Byull. Izobret., **2014,** *1*, 14.
3. Kolbanovskaya A. S., Mikhailov V. V., Dorognie bitumi; Transport, Moscow **1973**.
4. Livshitc R. M., Rudnaya G. V., Borisova I. N., Dobrovinskiy L. A., Babeeva Yu. N. *Russian coatings journal* **1983**, *1*, 12-13.
5. Varshaver E. M., Dumskiy Yu. V., Kozodoy L. V. *Plastifikatory i vosky* **1978,** 102 – 106.
6. Grynyshyn O., Astakhova O., Chervinskyy T. *Chemistry & chemical technology* **2010**, 4, 241-246.
7. Fryder I., Grynyshyn O., Khlibyshyn Y. *Proceedings of National Aviation University* **2013**, *4*, 135-138.
8. Bratychak M., Grynyshyn O., Astakhova O., Shyshchak O., Waclawek W. *Ecological chemistry and engineering,* **2010**, *17*, 309-315.
9. Slavgorodskaya O.,Bondaletov V. *Strategic Technology (IFOST), 7th International Forum on 18-21 Sept.* **2012**, 1-4.
10. Pyshyev S., Grytsenko Yu., Danyliv N., Bilushak H., Pyshyeva R. *Petroleum & Coal* **2015**, *57*, 303-314.
11. Dumskiy Yu. V., Berenz A. D., Kozodoy L. V., Mukhina T. M. Neftepolymernie smoli; CNIITEneftekhim, Moscow (1983).
12. Goncharova I. N., Donskaya N. A. Bitumnie vyagushie I materiali na ikh osnove: Metodicheskie ykazaniya; Kazan National Research Technological University, Kazan (2010).