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Oil and gas processing products to obtain polymers modified bitumen

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Abstract

To obtain modified bitumen with excellent adhesive properties, coumarone-indene resin (CIR) was used. However, bitumens modified by CIR have somewhat worse plastic properties. For the improvement of the plastic properties of road bitumen modified by coumarone-indene resin, the paper proposes to use plasticizers. Characterized by a high content of rings (aromatic-naphthenic oils), a range of compounds was used as plasticizers. Of all different plasticizers tested, the tar produced from West-Ukrainian oils has been found to be the most effective one. The optimal ratio between modified bitumen components was determined enabling to obtain the commercial product of polymers modified bitumen of BMP 60/90-52 brand. The complex thermogravimetry and differential-thermal analysis has been used to analyze the initial and modified bitumen. Bitumens modified by CIR have shown by far the highest thermal stability under operation conditions.

Keywords: Bitumen; Modifier; Coumarone-indene resin; Plasticizer

1. Introduction

The asphalt made of the petroleum-derived road bitumen is the most popular type of pavements. Though bitumen content is only 5–7 wt% by weight of pavement, the behavior of bitumen defines the properties of asphalt. Usual types of road bitumen cannot meet the demands of road infrastructure in terms of increasing traffic flows and climatic peculiarities [1–8].

To increase the quality of asphalt concrete paving, in the upper layer of the roadways it is recommended to use modified bitumen that compared with road bitumen (BND 60/90) has better physical and mechanical properties (Table 1).

Recently, there has been a great leap in application of polymer modified bitumens (PMBs) worldwide. They have greater elasticity, longer service life, lower brittleness temperature and higher softening point [1–8]. In some cases, the positive effect is achieved through modification by addition of those several materials to asphalt concrete mixes that improve certain parameters. For PMBs such components include a modifier (polymer), a plasticizer and surface-active additives [4].

The most popular modifiers are thermoplasts of styr ene–butadienestyrene type (SBS): *Kraton D* (*Kraton Polimers* company), *Calprene* (*Dynasol* company) and others [1–8]. Apart from the modifiers mentioned above the synthetic latexes of Butonal NS type (*BASF* company) and thermal polymer of Elvaloy type (*DuPont* company) has found wide application in Ukraine [3].

Researches by the Department of Oil and Gas Processing (Lviv Polytechnic National University) have proved the efficiency of employing coumarone-indene resin (CIR) as a polymer modifier. CIR is significantly cheaper than widely used commercial polymer additives [9–11].

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Table 1
Demands for usual (BND 60/90) and modified (BMP 60/90-52) petroleum bitumen in Ukraine.

Index	Standard for BND 60/90 bitumen according to DSTU 4044-2001 (EN 12591-1999)	Standard for BMP 60/90-52 bitumen according to DSTU BV.2.7.-135:2007	Procedure*
Homogeneity	Non standardized	Homogeneous	According to point 9.3 DSTU BV.2.7.-135:2007
Penetration at 25 °C (m × 10^{-4})	61–90	61–90	GOST 11501
Softening point (ball & ring method) (°C)	47–53	≥52	GOST 11506
Ductility (m × 10^{-2})			GOST 11505
At 25 °C	≥55	≥25	
At 0 °C	≥3	≥5	
Elasticity at 25 °C (%)	non standardized	≥50	According to point 9.5 DSTU BV.2.7.-135:2007
Brittleness temperature (°C)	≤−12	≤−15	GOST 11507
Flash point determined in open firepot (°C)	≥230	≥230	GOST 4333
Change of properties after heating:			
Change of weight after heating (%)	≤0.8	Non standardized	GOST 18180 with supplement according to point 8.3 DSTU 4044–2001
Residual penetration (%)	≥60	≥60	GOST 11501 with supplement according to point 8.4 DSTU 4044-2001
Change of softening point (°C)	≤6	≤6	GOST 11506 with supplement according to point 8.5 DSTU 4044-2001
Adhesion to glass (%)	Non standardized	≥75	DSTU B V.2.7 – 81 with supplement according to point 8.6 DSTU 4044-2001
Destruction while storage:			According to point 9.8 DSTU BV.2.7.-135:2007
Difference between softening points (°C)	Non standardized	≤6	
Difference between penetrations at 25 °C (m × 10^{-4})	Non standardized	≥60	
Mass part of paraffins (wt.%)	Non standardized	Non standardized	GOST 17789
Solubility in organic solvents (%)	≥99.00	Non standardized	GOST 20739
Penetration index	−2.0 to +1.0	Non standardized	According to point 8.7 DSTU 4044-2001

* DSTU and GOST – Ukrainian national standards.

Addition of CIR to bitumens allows softening points to be significantly increased (from 47 to 58 °C) and improves adhesion properties. On the other hand, the use of modifiers adversely affects the plastic properties of the bitumen (ductility and penetration diminish). In order to solve this problem, plasticizers along with modifiers are usually added to a bitumen composition.

For this reason, the researches covered in the present paper deal with the ways of utilizing plasticizers in blends of bitumen and CIR.

2. Experimental

To obtain PMB, commercial bitumen of BND 60/90 for road constructions, which was produced by Lviv asphalt-bitumen storehouse, was used. Bitumen characteristics are represented in Table 2.

CIR was used as a modifier. CIR is obtained from a chemical product of coal charge coking, the characteristic of which depends on composition and quality of coal [12,13]. The synthesis procedure of coumarone-indene resins are given in [9–11]. Depending on synthesis conditions and the composition of initial raw material different CIRs were obtained. Some main properties of CIR are given in Table 2.

A range of compounds with a relatively high content of aromatic-naphthenic based oil were used as plasticizers for the modified bitumen (Table 2), in particular:

- Tars produced from West-Ukrainian and Orkhovitska oils taken at West-Ukrainian refineries.
- Distillation extract of selective treatment by furfurol and residual extract of selective treatment manufactured by *Ukrtatnafta*, JSC.
- Resin after lignite thermodestruction.
- SAE-140 transmission oil.

Resin derived from thermodestruction of lignite is one of the products obtained in the process of oxidative desulfurization [14–16].

The laboratory unit intended to obtain PMB is shown in Fig. 1. PMB has been prepared in the following way. A necessary amount of bitumen was heated to 110 °C. Then the modifier and plasticizer were added in a required amount and stirred for 1 h at Re = 1200.

Chemical group composition of the bitumen was analyzed by the Marcusson method [17]. The type of the structure of the bitumen sampled was determined according to this procedure [18] (Table 3).

Technical parameters of the raw material and products were determined according to standard procedures (see