THE INFLUENCE OF BITUMEN'S CHEMICAL COMPOSITION IN BITUMEN/APP COMPOUNDS FOR WATERPROOFING PURPOSES

RODRIGUEZ DE SANCHO ISABEL and BLANCO FERNANDEZ MANUEL
Central Laboratory of Materials and Structures (CEDEX)
Madrid, Spain

This paper will evaluate the influence the chemical composition of bitumen exerts on bitumen/APP compounds used for waterproofing purposes.

Three bitumens of penetration, range 150/200, from different origins (Iran, Arabia and Mexico) were chosen. Chemical composition analysis, rheological and technical properties were evaluated.

Molecular weights and aromaticity were determined for each fraction.

The atactic polypropylene used for the modification is a by-product of propylene polymerization. It was characterized before being added to bitumens.

After bitumen modification, bituminous membranes were elaborated in the laboratory. Membrane characteristics such as dimensional stability, flow resistance, low temperature flexibility, elongation and strain energy were determined.

A relationship between the original bitumens chemical composition and bituminous membrane performance may be found. For this reason, the knowledge of original bitumen composition could be used as a predictor of a better performance of polymer-modified bituminous roofing membranes.

KEYWORDS

APP, bitumen, chemical composition, bitumen/APP compounds, penetration, softening point, ductility, Fraass breaking point.

EXPERIMENTAL

Three bitumens from different origins—Iran, Saudi Arabia and Mexico—were evaluated in this work. Routine test methods such as penetration, softening point, Fraass breaking point, ductility, etc., were determined.

For determining rheological properties of bitumen and modified bitumen, a capillary rheometer system, has been used.

Chemical analysis was achieved in accordance with ASTM D 4124. This method covers the separation of four defined fractions from bitumens, established as: asphaltenes, saturates, naphtenes aromatics and polar aromatics. Chemical composition was obtained using a microcarbon-hydrogen-nitrogen determinator. Molecular weights of the different fractions were determined by a vapor pressure osmometer. Each fraction was characterized by ^{13}C-n.r.m. spectroscopy.

Bitumen/APP compounds were obtained after mixing the melted components in a metal container at 169°C for four hours, using 300 rpm as the mixing velocity. Proportions 95/5, 85/15, 75/25 and 70/30 (bitumen/APP) were prepared for each bitumen.

The APP used is a by-product of propylene polymerization.[1]

After bitumen modification, technological and rheological properties were evaluated again. A new bituminous waterproof substance, which is more flexible at low temperatures and more resistant to the adverse influences of high temperatures, was obtained.

These new compounds were used for the elaboration of a bituminous sheet suitable for single-ply roofing. Bituminous membranes (APP/bitumen 30/70) were elaborated in the laboratory. Membrane characteristics such as dimensional stability, flow resistance, low temperature flexibility and ageing resistance were determined.

RESULTS AND DISCUSSION

Table 1 shows technological properties of original and modified bitumens.

The values of penetration index point out that properties of bitumens improve considerably when the APP proportion increases.

In general, the addition of APP to bitumen[2] improves its physical-mechanical properties; lower penetration values and higher softening points have been measured, the range of plasticity becomes wider and the thermal resistance becomes higher.

Table 2 shows viscosity values for original and modified bitumens for a constant value $D^{3}70.8\ s^{-1}$ (shearing rate), calculated from rheological measurements.[3,4]

Table 3 shows chemical fractions of bitumens and Table 4 shows molecular weights of fractions. Those fractions were characterized by ^{13}C- n.m.r, which provides a direct and accurate value of aromatic carbon as a fraction of the total carbon.[5,6]

The bitumen which reached better properties after modification, was the one from Iran. This bitumen had higher content in asphaltenes (12.5 percent) in relation to 7.9 percent and 8.4 percent (Arabia and Mexico, respectively). The aromaticity of the napthenic aromatic and polar aromatic fractions were higher for this bitumen also, but the content of the naphtenic aromatic fraction (34.87 percent) is lower with regard to values for Arabian and Mexican bitumens (Table 3).

For each bitumen, three kinds of membranes were elaborated in the laboratory, one without felt and two with glass fiber felt (60 g/m²) placed MD and XD.

After membrane elaboration, several properties were checked (Table 5). According to the results obtained and taking into account Spanish Standardization,[7] the membranes could be manufactured in industry.

The results in Table 5 show that elongation is higher in the Mexico and Arabia bituminous samples, and the naphtene aromatic fraction (percent) is higher for these two bitumens. As this fraction gives ductility to the bitumen, when its amount (percent) increases, elongation increases.

On the other hand, strain energy is higher for Iranian bitumen. This bitumen has an aromaticity and asphaltene content higher than the others. These facts could be the reason for better values of technological properties and strain energy.

CONCLUSIONS

The addition of APP improves technological characteristics of bitumens: cohesive strength, resistance to flow at high temperatures and toughness, imparts flexibility and elasticity.

Technological properties evaluated for the three modified bitumens fulfil the Spanish Standardization 7 for modified bitumens. Consequently, these modified bitumens could be used for the elaboration of membranes.

Chemical composition of bitumen can give an idea of the variations of technological properties in order to match the product with the purpose of which it is intended.

Low temperature flexibility could be improved by the addition of copolymers to the initial modified bitumens. These improvements and the extension of the study to many origin bitumens is underway.

ACKNOWLEDGMENT

The support of this research by C.I.C.Y.T. (Interministerial Commission of Science and Technology) is gratefully acknowledged.

REFERENCES

1. I. Rodriguez and M. Blanco, Ingenieria Civil, No. 73, pp. 5-12, 1990.
2. A. Bukowski and K. Piotrowska, Japan Conference on Polymers and Plastics, pp. 71-74, 1980.
3. Zielinski, Wissenschaft and Technic, Bd 41, Heft 6, 1988.
4. C. Lomi and F. Uarisco, Eurobitumen, Madrid, 1988.
5. D. R. Clutter, L. Petrakis et al, Anal Chem, Vol. 44, No. 8, 1972.
6. Yan Jia-Ji, "The relationship between bituminous chemical structures and physical properties," Roofs and Roofing, Ellis Horwood Publishers, 1988.
7. UNE 104-242-89, "Waterproofing bituminous and bituminous modified materials, Modified bitumen sheets with plastomers."

	Iranian Bitumen					Arabian Bitumen					Mexican Bitumen				
Characteristic	**Origin**	**95/5**	**85/15**	**75/25**	**70/30**	**Origin**	**95/5**	**85/15**	**75/25**	**70/30**	**Origin**	**95/5**	**85/15**	**75/25**	**70/30**
Penetration 25°C, 100g, 5s, 0.1mm.	150	105	52	45	30	164	127	62	44	31	159	110	61	45	29
Softening Point °C	40	51	79	110	121	39	45	57	90	113	42	48	71	96	112
Fraass Breaking Point, °C	−13	−13	−15	−16	−16	−10	−11	−11	−14	−14	−11	−12	−13	−16	−16
Penetration Index	−1.2	1.2	4.3	7.3	7.3	−1.3	0.1	1.0	5.3	6.9	−0.2	0.5	3.6	6.1	6.5
Ductility, 25°C,cm.	►100	67	16	5.5	5.0	►100	79	38	18	6.0	►100	84	21	15	6.5

Table 1 Technological characteristics of original and modified bitumens.

	Iranian		Arabian		Mexican	
T °C	**Origin**	**75/25**	**Origin**	**75/25**	**Origin**	**75/25**
60	36	469	29	372	11	388
65	19	299	180	218	5	300
70	13	194	12	170	2	162
75	10	129	9	97	0.7	97
80	6	90	6	7.4	0.3	68

Table 2 Viscosities (Pa's) vs. Temperatures (°C).

	Iranian	Arabian	Mexican
Asphaltenes	12.50	7.90	8.50
Saturates	23.53	18.45	15.55
Napthenes Aromatics	34.87	53.61	45.97
Polar Aromatics	28.92	19.94	29.73

Table 3 Chemical fractions of bitumens (%).

	Iranian		Arabian		Mexican	
	Mn	Car/Cal	Mn	Car/Cal	Mn	Car/Cal
Asphaltenes	3657	0.84	3601	0.83	3546	0.82
Saturates	681	—	653	—	662	—
Napthenes Aromatics	803	0.64	841	0.55	877	0.43
Polar Aromatics	1052	0.80	1114	0.51	1230	0.52

Table 4 Molecular weight of fractions Mn and Car/Cal relationship.

	Iran			Arabia			Mexico		
Characteristic	**MD**	**XD**	**WF**	**MD**	**XD**	**WF**	**MD**	**XD**	**WF**
Weight kg/m²	4.2	3.6	3.0	3.2	3.4	3.4	3.8	3.6	3.4
Pliability (−10 °C)	G	G	G	G	G	G	G	G	G
Dimensional stability 2h, 80°C, %	I	I	0.1	I	I	0.1	I	I	0.1
Elongation (break) %	—	—	91	—	—	113	—	—	115
Strain energy kPa.	269	211	42	270	210	35	269	207	36
MD, machine direction	XD, cross machine direction			WF, without felt			G, good	I, imperceptible	

Table 5 Characteristics of bituminous membranes.