International Journal of Engineering & Scientific Research
Vol. 10 Issue 7, July 2022,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://esrjournal.com, Email: esrjeditor@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Utilization of recycled plastomers for modification of bitumen binder

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ABSTRACT

The use of plastics from one side of the world to the other has remained at an incredibly significant level over the years, creating serious common profanity without any alternative method of organizing and reusing. The reuse of plastic waste has been proposed as an unrivaled technology, different from the various systems for their handling, for example, waste treatment, consumption, or landfilling. Despite having a reuse rate of 75% from surrounding residents, only 3.14 million tonnes (9.1%) were recycled, while 5.35 million tonnes (15.5%) of plastics were used for energy recovery and 26.01 million tonnes (75.4 %). %) Plastics were combusted. In this article Recycled EVA polymers are used in the present work, because of its better compatibility with bitumen, LDPE for stiffness, homopolymer propylene (HPP), cast polypropylene (CPP), polyetherpolyurethane (PEPU), truck tyre rubber (TTRB) and styrene butadiene styrene (SBS) are used for modification of bitumen binder either as individual polymer or in combination of two, to improve service performance of road pavements..These polymer modified binders are evaluated on conventional, rheological and viscoelastic parameters.

Keywords: Plastic, Plastomer, Bitumen

Introduction

Polymers are recycled by two techniques, i.e. mechanicalrcycling or reuse and chemical recycling, in which the composition and structure of plastomer is altered and also utilized as feedstokes. In mechanical recycling only the thermoplastic polymeric wastes are used, because they have the specialty of re-melting and mouliding into end products[1].The mechanical recycling does not involve alteration of polymer type during the recycling process. In this physical type process, plastic waste is collected, called as primary process, and then shredding, washing and granules or pellets as required are produced. These granules or pellets are then extruded into new products. To achieve superior quality of plastomers, these granules can be blended with virgin polymer. Because mechanical recycling involve many steps, there is chance of reduction in quantity of material and degradation polymeric properties, also due to incision of polymeric chain[2, 3].In chemical recycling, the waste polymers are altered to its constituents or depolymerised to oligomers through chemical conversion. The obtained monomers or oligomers can be either used directly or as feedstockes[3- 5].There are some processes to reuse, including pyrolysis and gasification. In any case, the most regularly taken up framework for plastic reuse is mechanical reuse; the result is clean and joined by pellet-structure recycled saps and pellet-structure recycled gums everywhere[6].The chemical recycling of polymeric wastes is accepted widely because of higher processing cost, however some chemical process like glycolysis and methanolysis have attracted industrialists[3, 7-9]. The reuse structure starts with the realm of post-purchaser and post-present plastic waste. Social opportunity and construction firms regularly explore mixed relationships by reusing ties as systems for takeoff to meet the natural safety regulations shown by ISO standards.

Plastic waste is recycled more effectively than the present day, because plastic waste is linked to every interesting connection, the plastic waste well is usually the result of the treatment of express plastics, which does not require additional straightening, it occurs. Kerbside gathering is a type of post-purchaser plastic waste sort of argument, allowing plastic reuse firms to set up a mix plan to connect households to collect widespread and reusable family waste at neighborhood barricades[10].

The Reuse Association collects plastic waste from chamber controlled simple waste system drop-off centers that grants buyers the option to dispose of individual household plastic waste as an alternative to kerbside collecting. In unsuspecting countries, post-purchaser plastic waste is composed by specific verification sections prior to kerbside assembly. By far most of the plastic recycled and reused from one side of the world to another is coming from post-current plastic streams rather than post-clients. Huge pieces of plastic are dismantled and dropped into extra straight pieces before they are washed or cleaned. The correction of turning sharp edges driven by an electric motor with unequal associations to the degree of shape unites the most well-known method for managing skewing[11].

The material is shredded in a shredder to make thick unusual shaped plastic pieces. Since waste plastics come in a variety of schemes, prominently delegating unflinching and versatile plastics, today's shredders in the first category can be assigned to dissimilar plastics. Despite this, adaptable plastics require express shredders in light of the delicate and film-like turn of events. The film plastic tear would convey the pollution inside the pockets of the films beyond a shadow of a film[12].

With the increment in population, the demands of packaging and other commodities are increasing at very high speed worldwide. In packaging plastomers are mostly used, which is the cause of huge accumulation plastic wastes, creating threatening to the environment and human health. To avoid such circumstances, the best way is to utilize this waste in various sectors such as construction, energy production, pavement[13], etc.

Many researchers have used these recycled plastic wastes to improve the quality and service life of roadways[14]. By using these recycled polymeric wastes for modification of bitumen binders instead of virgin polymers, a sustainable, economical and environment friendly development can be achieved[15].

The use of numerous plastic wastes as modifiers for bitumen have been reported in literature like high-density polyethylene (HDPE)[16-18], ethylene vinyl acetate (EVA)[14, 19, 20], low-density polyethylene (LDPE)[21], polypropylene (PP)[21, 22], acrylonitrile butadiene styrene (ABS)[23], polyvinyl chloride(PVC)[22-24], polyethylene terephthalate – PET)[25-27] and recycled tyre crumb rubber[28-32].

The incorporation of polymers and its perfect blending with bitumen binder is influenced by several factors like polymer content[34, 35], characteristics of polymer and bitumen, processing time and temperature and mixer type[36]. Therefore to obtain the desired properties of polymer modified bituminous binder, some researchers have focused on the miscibility of bitumen and polymer and also on the interaction of their, so that a homogeneous bituminous binder can be produced[37]. However more advancement is required in the use of waste polymer for modification of bitumen binder, so that a better binder can produce, having the service performances similar to virgin polymer.

Recycled EVA polymers are used in the present work, because of its better compatibility with bitumen[33], LDPE for stiffness, homopolymer propylene (HPP), cast polypropylene (CPP), polyetherpolyurethane (PEPU), truck tyre rubber (TTRB) and styrene butadiene styrene (SBS) are used for modification of bitumen binder either as individual polymer or in combination of two, to improve service performance of road pavements..These polymer modified binders are evaluated on conventional, rheological and viscoelastic parameters.

Materials

Bitumen

The penetration grade bitumen (200dmm) from two sources; Bitumen A and Bitumen B was collected from refineries. A commercial modified binder coded as M75, containing SBS was procured from local market. Classification of base bitumens is given in table 1.

Table 1.Clasification of base Bitumens

Property	Bitumen A	Bitumen B	M 75	100 pen. Bitumen
Softening point (^{0}C)	39.2	37.5	70	44.2
Penetration (dmm)	184	185	98	110
Viscosity (Poise)				
135^{0}C	2.1	2.14	7.7	3.10
150^{0}C	1.3	1.3	4.72	1.55
180^{0}C	0.45	0.45	1.95	0.6
195^{0}C	0.29	0.29	1.35	0.45

Waste Polymers

Recycled polymers, EVA, LDPE, HDPE, CPP and HPP are used and their properties are given in table 2. Polyetherpolyurethane(density 1.09 g/cm^3), was procured from nearby industry. The reclaimed truck tyre rubber (particle sizes are less than 200μmand density is 1.1-1.2 g/cm^3) was supplied by a tyre recycling industry, the properties of which are given in table 3. 14%, 20% and 33% of vinyl acetate were present in EVA1, EVA2 and EVA3 respectively.

Preparation of samples

The bitumen and recycled polymers were blended in a double jacketed vessel fitted with peddle type high shear mixer 750 rpm. The blending time and temperature was varied for different modifiers such as LDPE, HDPE and EVA (45 min., 165^{0}C), CPP and HPP (45 min., 175^{0}C). Commercial bitumen binder M75 was blended with LDPE at 1750C for 90 minutes. PEPU and TTRB were blended for a similar amount of time but at 200°C.

Table 2. Properties of HPP, CPP, LDPE and HDPE

Property	HPP	CPP	LDPE	HDPE
Density (g/cm^3)	0.921	0.91	0.952	0.953
Melting Point (^{0}C)	164.1	163.9	115	129.1
Melt flow index (g/600s)	19.22 (at 190^{0}C)	3.64 (at 190^{0}C)	36.06 (at 230^{0}C)	31.2 (at 230^{0}C)

Testing Strategies

These blends were examined for conventional tests like viscosity, softening point (ASTM D 36-09) and penetration (ASTM D 5-06) as per existing standard specifications. Then the ageing susceptibility and rheolgical studies of these blends were carried out. The rolling thin film oven test (RTFOT) was carried out as described in CEN (1997).

Table 3. composition of TTRB[11]

Material	Content (wt %)
Natural rubber	25-50
SBRand butadiene	5-30
Carbon black	25-30
Proceeing oils	20-25
Benzene extraction	3.5-9
Acetone extraction	10 (max.)
Ash content	4-6

RESULT

The penetration value of bitumen is the parameter of stiffness of bitumen and its binder. The high value of penetration shows that the bitumen can be penetrated easily, while value of penetration means, bitumen is hard. The table 4 suggests that the penetration of all blends is decreasing with increase of polymer content in the blends i.e. the stiffness of blend is increasing. It is appears from the table4 that none of EVA 3 blends is able to decrease the penetration value of base bitumen. Similar values of penetration are obtained from both the Bitumen A&B. The penetration value of blend with EVA 3 is ranges from 137 to 157 dmm , relatively high, while this value is around 100 dmm for EVA 2 with bitumen B, , but 86 dmm penetration value of blend with Bitumen A indicates an increase in stiffness.

Table 4.penetration valves of EVA and LDPE blends with Bitumen A& B

Type of Bitumen binder	Penetration (dmm)
A 2% EVA1+ 4% LDPE	137
B 2% EVA1+ 4% LDPE	101.5
A 4% EVA 1+ 2% LDPE	96
B 4% EVA 1+ 2% LDPE	117
A 2% EVA 2 + 4% LDPE	86
B 2% EVA 2 + 4% LDPE	102
A 4% EVA 2+ 2% LDPE	86
B 4% EVA 2 + 2% LDPE	101
A 2% EVA 3+ 4% LDPE	152
B 2% EVA 3+ 4% LDPE	137
A 4% EVA 3+ 2% LDPE	157
B 4% EVA 3+ 2% LDPE	153

It is evident from the table 5 generally softening point of all blends are increasing with increased content of polymer. The blends of bitumen with CCP showed highest increase in softening point of binder. The softening point of commercial bitumen binder M75 and LDPE modified bituminous binders are given in table 6. It is evident from this table that as the amount of SBS from binder M 75 is replaced with LDPE, the softening point of blends increases. The softening point of blend M 75 -1% SBS &3% LDPE was 74^{0}C and the blend M 75 & 2%LDPE was shown slightly increased in softening (75.7^{0}C).

Table 5 softening points of various bitumen binders

Blends with bitumen	Softening point (^{0}C)
HDPE	47
LDPE	68
HPP	43
CPP	82
EVA 1	66
EVA 2	61
EVA 3	38

The softening point of commercial bitumen binder M75 and LDPE modified bituminous binders are given in table 6. It is evident from this table that as the amount of SBS from binder M 75 is replaced with LDPE, the softening point of blends increases. The softening point of blend M 75 -1% SBS &3% LDPE was 74^{0}C and the blend M 75& 2%LDPE was shown slightly increased in softening (75.7^{0}C).

Table 6. Softening point of blends of LDPE and commercial bitumen binder

Bitumen binder	Softening point (^{0}C)
M 75-1% SBS + 1% LDPE	68.0
M 75-1% SBS + 2% LDPE	65.8
M 75-1% SBS + 3% LDPE	74.0
M 75-2 % SBS + 2 % LDPE	46.2
M 75-2 % SBS + 3 % LDPE	56.9
M 75-2% SBS + 4% LDPE	59.2
M 75 + 1% LDPE	75.0

Viscosity of bitumen binders is parameter of sufficient workability to coat on the aggregate orsurface. In table 7 the viscosity of EVA and LDPE blend are given. The mixtures of EVA 1 and LDPE show increased viscosity value in comparison with EVA 1 blends. The combinations of EV A2 and LDPE show similar viscosity values as found with 6% EVA 2 results whereas the EVA3 and LDPE blends are similar to the 6%EVA3 results.

Table 7. Viscosity of EVA and LDPE blends with both Bitumen A & B

Viscosity (Poise)	2% EVA1+ 4 % LDPE, A/B	4% EVA1+ 2 % LDPE, A/B	2% EVA2+ 4 % LDPE, A/B	4% EVA2+ 2 % LDPE, A/B	2% EVA3 + 4 % LDPE, A/B	4% EVA3+ 2 % LDPE, A/B
135^{0}C	5/5.2	4.3/3.8	6.66/6.05	6.5/6.05	5.8/5.4	5.7/5.3
150^{0}C	2.8/3.01	2.50/2.24	3.9/3.4	4/3.50	3.4/3.16	3.1/3.05
180^{0}C	1.2/1.13	1.1/0.9	1.55/1.34	1.5/1.44	1.4/1.19	1.2/1.18
195^{0}C	0.85/0.85	0.7/0.65	1.05/0.9	1.1/0.98	1.1/0.98	0.9/0.77

Discussion

Plastomers are commonly used as bitumen modifiers due to their lower cost – different from elastomers – as well as their superior strength, therefore limited to key areas of strength at high temperatures; Clearly, cram. One of the constraints in the use of plastomeric transformation is the stage bundle due to the low comparison of polymers with bitumen, which yields two distinct phases, that is, the asphalt-rich phase and the polymer-rich phase. Despite this, limit strength is routinely an issue for deceptively inert and non-polar plastics, for example, polyolefins, yet when these plastics are mixed with polar materials the end energy turns into a more honest issue. gets changed. The stage pack's equipment can be better visualized by focusing on the polymer-bitumen worked with the effort.

During the polymer-bitumen transformation, a truly surprising and thermodynamically conflicting growth is molded, where the polymer is loosened by the maltene part of the bitumen. This thermodynamically anomalous system induces phase splitting in light of gravitational field effects, achieving settlement of heavy asphaltene micelles at the bottom of the mixtures during hot static care.

All plastomers show an originally ambiguous model when added to bitumen. Extended viscosity and it were obvious to loosen point and low penetration. Some plastomers were more useful than others. The EVA3 was the most unusable added material with a 6% plastic content, reducing base bitumen penetration to 137dmm and loosening vanity feature 52.2 °C.

Mixing the plastomers was the most troublesome. The 11% plastic mixture showed little improvement in the properties of the base bitumen. It should be seen that the 5% additional plasticity correction gave monster property results as the 11% mixture appeared more flexible than the 16% mixture.

Conclusion

The general performance, strength credit as well as failure of faint top blends basically depend on the properties of the bitumen. Further strength and performance of the binder are surprisingly expected, thus significant undertakings are being established in the polymer transformation of bitumen. Particularly at high temperatures, plastomers are used in light of the somewhat irrelevant cost and surprising strength. Recently, the use of recycled plastomers continues to be of equally lucrative interest, perhaps joining the more significant routine challenges posed by waste plastics.

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