(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 December 2006 (28.12.2006)

PCT

(10) International Publication Number
WO 2006/136436 A1

(51) International Patent Classification:
C08J 5/00 (2006.01)

(21) International Application Number:
PCT/EP2006/006070

(22) International Filing Date: 23 June 2006 (23.06.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/693,437 24 June 2005 (24.06.2005) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2006/136436 A1

(54) Title: STYRENE BLOCK COPOLYMERS AS INFILL MATERIAL IN ARTIFICIAL TURF SYSTEMS

(57) Abstract: The present invention relates to the use of styrene-isobutylene block copolymers or styrene isoprene block copolymers as infill material in artificial turf systems. The styrene-isobutylene block copolymers preferably comprise 70-85-wt% p-isobutylene based on the total weight of the styrene-isobutylene block copolymer. Preferably the styrene-isobutylene or styrene isoprene block copolymers further comprise a polyolefin and/or a styrene based thermoplastic elastomer. The polyolefin is chosen from a polyolefin homopolymer, a polyolefin copolymer or a polyolefin composition. The styrene based thermoplastic elastomer is chosen from SBS or SEBS. The content of the styrene-isobutylene block copolymers or styrene isoprene block copolymers, the polyolefin and/or the styrene based thermoplastic elastomer is chosen in that way that the hardness varies between 40 and 90 Shore A. The infill material is usefull in soccer fields, hockey fields, rugby fields or tennis fields.

STYRENE BLOCK COPOLYMERS AS INFILL MATERIAL IN ARTIFICIAL TURF SYSTEMS

The present invention relates to the use of styrene block copolymers as infill material in artificial turf systems.

Artificial turf has achieved growing popularity in recent years, particularly for football fields. An important reason for this trend is a new generation of artificial-turf systems, in which fibres with low sliding resistance are utilised in combination with elastomer material as infill material. Styrene block copolymers as infill material for artificial turf structures are for example known from EP-A-1386944. In EP-A-1386944 styrene-ethylene-butylene-styrene, styrene-ethylene-propylene-styrene and styrene-ethylene-ethylene-styrene block copolymers are disclosed as compaction material for synthetic lawn.

Over the last years the artificial turf systems, for example artificial grass, have been improved using new developments in fibre technology, infill materials, tuft technology and total system installations. However still a lot of disadvantages exists namely in reaching the desired level of properties as for example energy restitution and vertical ball rebound. These properties are still not sufficient to provide an artificial turf system with the performance of natural turf.

The object of the present invention is to overcome the above stated drawbacks and to provide an infill material for an artificial turf system, which reproduces more the characteristics of a natural turf system for football or rugby, as required in respectively the FIFA 2 star/1star (1 July 2004) and IRB regulations (April 2004) on artificial turf.

This object is achieved by the use of styrene-isobutylene block copolymers or styrene-isoprene block copolymers as infill material in artificial turf systems.

Surprisingly, it has been found that the use of styrene-isobutylene block copolymers (SIBS) or styrene-isoprene block copolymers as infill material in artificial turf systems provides artificial turf systems with an improved ball rebound and a better energy restitution.

The styrene-isobutylene block copolymer for example comprises between 60-95-wt% of p-isobutylene based on the total weight of the block copolymer. Preferably between 70-85 wt% of p-isobutylene based on the total weight of the blockcopolymer. The block copolymers are polymerised by cationic living

polymerisation. Styrene-isobutylene block copolymers or SIBS are commercially available for example from Kaneka under the trademark SIBSTAR®.

The styrene-isoprene block copolymers for example comprise polystyrene blocks and polyisoprene or vinyl-polyisoprene blocks. It is also possible that the polyisoprene or vinyl-polyisoprene blocks are hydrogenated. Preferably the styrene-isoprene block copolymers are tri-block copolymers. Those tri-block copolymers are commercially available from for example Kuraray Co. under the tradename Hybrar™.

The styrene-isobutylene block copolymers or styrene-isoprene block copolymers may for example further comprise a polyolefin and/or a styrene based thermoplastic elastomer. It is thus possible that the SIBS block copolymers or styrene-isoprene block copolymers comprise both a polyolefin and a styrene based thermoplastic elastomer.

The polyolefin may be chosen from polyolefin homopolymers, polyolefin copolymers or a polyolefin composition. Examples of homopolymers are polyethylene, polypropylene, and polybutylene. Examples of polyolefin copolymers are for example ethylene-alpha-olefin copolymers in which the alpha-olefin comprises between 3-10 C-atoms. Examples of ethylene-alpha-olefin copolymers are ethylene-vinylacetate, ethylene-vinyl alcohol, ethylene-propylene copolymers or ethylene-butylenes copolymers. The ethylene-propylene copolymers may for example comprise between 75-95-wt% of propylene based on the total weight of the ethylene-propylene copolymers.

Examples of the polyolefin composition are polyolefin compositions comprising 20-50 parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100. More preferably, the polyolefin compositions comprise between 20 and 40 parts by weight of a crystalline polyolefin and between 60 and 80 parts by weight of an elastomer whereby the total parts by weight is 100.

The crystalline polyolefin is preferably selected from a polypropylene homopolymer or an ethylene-alpha-olefin copolymer. Preferably, the alpha-olefin is selected from the group comprising propylene, 1-butene, 1-hexene, 1-octene and 4-methyl-1-pentene. Among these, propylene and 1-butene are preferred.

The elastomer is preferably selected from the copolymers of ethylene with alpha.-olefins CH_2 =CHR in which R is alkyl having 1 to 6 carbon atoms. More preferably, the alpha.-olefin is propylene or butene. The content by weight of units

derived from ethylene is preferably between 40 and 70%, more preferably between 50 and 70% most preferable between 60 and 70%. The content by weight of units derived from alpha.-olefins is preferably between 30 and 60%, more preferably between 30 and 50%, most preferably between 30 and 40%. Particularly preferred are the copolymers, which contain 0.1 to 20% by weight, preferably 1 to 10%, of units derived from a polyene. Such a polyene can be selected from the group comprising trans-1,4-hexadiene, cis-1,4-hexadiene, 6-methyl-1,5-heptadiene, 3,7-dimethyl-1,6-octadiene and 11-methyl-1,10-dodecadiene; monocyclic diolefins such as, for example, cis-1,5-cyclooctadiene and 5-methyl-1,5-cyclooctadiene; bicyclic diolefins such as, for example, 4,5,8,9-tetrahydroindene and 6- and/or 7-methyl-4,5,8,9-tetrahydroindene; alkenyl- or alkylidene-norbornenes such as, for example, 5-ethylidene-2-norbornene, 5-isopropylidene-2-norbornene and exo-5-isopropenyl-2-norbornene; polycyclic diolefins such as, for example, dicyclopentadiene, tricyclo[6.2.1.0^2,7]4,9-undecadiene and the 4-methyl derivative thereof, 1,4-hexadiene, isoprene, 1,3-butadiene, 1,5-hexadiene, 1,6-heptadiene and so on. Among these, 5-ethylidene-2-norbornene is preferred.

The elastomer can advantageously be prepared by polymerising mixtures of ethylene, alpha-olefin and, if appropriate, polyene in the presence of a catalytic system comprising for example a metallocene catalyst and an alumoxane.

The polyolefin compositions can be prepared by directly in the reactor by means of sequential polymerization. The compositions obtained according to this technique in fact show better elastomeric properties than those of the compositions obtained by simple mechanical mixing. These polyolefine compositions, also known as reactor TPO's, are commercially available for example under the tradename Hifax®.

The use of styrene-isobutylene block copolymers or styrene-isoprene block copolymers and a polyolefin composition comprising 20-50 parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100, as infill material is preferred. The use of styrene-isobutylene block copolymers or styrene-isoprene block copolymers with an ethylene-alpha-olefin as infill material is even more preferred.

The styrene based thermoplastic elastomers are for example block copolymers or terpolymers having one or two terminal polymeric blocks of for example polystyrene or poly-alpha-methylstyrene, and at least one non-terminal block of an elastomeric polymer, for example polybutadiene or polyisoprene. Typical examples of such block copolymers are those of general form polystyrene-polybutadiene-polystyrene (SBS), polystyrene--poly(ethylene/propylene) (SEP), poly-alpha-

methylstyrene-polybutadiene-poly-alpha-methylstyrene, polystyrene-ethylene-propylene-polystyrene (SEPS), polystyrene-poly(ethylene/butylenes)-polystyrene (SEBS), polystyrene-poly(ethylene/ethylene/propylene)-b-polystyrene (SEEPS), or crosslinkable styrenic block copolymers produced by Kuraray Co., Ltd under the trade name Septon V. These styrene block copolymers are commercially available from Kraton Polymers LLC under the trademark KRATON and from Kuraray Co., Ltd under the trade name Septon. Preferably polystyrene-poly(ethylene/butylenes)-polystyrene (SEBS) or polystyrene-polybutadiene-polystyrene (SBS) is used as styrene based thermoplastic elastomer. The use of styrene-isobutylene block copolymers or styrene-isoprene block copolymers and SBS or SEBS as infill material is preferred.

The content styrene-isobutylene block copolymers or styrene-isoprene block copolymers, polyolefin and/or styrene based thermoplastic elastomer may be chosen in that way that the hardness of the total composition varies between 40-90 Shore A. Preferably the Shore A hardness varies between 50-70. Also in case that the styrene-isobutylene block copolymers or styrene-isoprene block copolymers comprise a polyolefin and a styrene based thermoplastic elastomer the content of the styrene-isobutylene block copolymers, styrene-isoprene block copolymers, the polyolefin and the styrene based thermoplastic elastomer is to be chosen in such a way that the hardness of the total composition varies between 40-90 Shore A. Preferably the Shore A hardness varies between 50-70.

The styrene-isobutylene block copolymers or styrene-isoprene block copolymers may optionally comprise customary additives. Examples of such additives are reinforcing and non-reinforcing fillers, plasticizers, antioxidants, stabilizers, oil, antistatic agents, waxes, foaming agents, pigments, flame retardants and other known agents and are described in the Rubber World Magazine Blue Book, and in Gaether et al., Plastics Additives Handbook (Hanser 1990). Examples of suitable fillers are calcium carbonate, clay, silica, talc, titanium dioxide, and carbon.

Examples of suitable oils are paraffinic oil or naphthenic oil obtained from petroleum fractions. As paraffinic oil for example Sunpar ™ oil can be used. Also highly hydrogenated oil in which the concentration of aromatic compounds is preferably less than 4 wt.% and the concentration of polar compounds is less than 0.3 wt.% can be used. An example of such oil is PennzUltra™ 1199, supplied by Pennzoil in the United States of America.

The infill material according to the present invention is preferably used as a granulate having a shape defined on the Krumbein scale with a sphericity in

the range of 0.7-0.9 combined with a roundness of at least 0.7 and a length/diameter (L/D) ratio between 0.8-1.2 whereby the granules have a uniform particle size.

The styrene-isobutylene block copolymers or styrene-isoprene block copolymers optionally in combination with a polyolefin and/or styrene based thermoplastic elastomer as set out above are useful as infill material in soccer fields, hockey fields, rugby fields or tennis fields.

The present invention further relates to a composition of a styrene-isobutylene block or styrene-isoprene block copolymer, a polyolefin and/or styrene based thermoplastic elastomer.

The polyolefin is described above. Preferred is a composition comprising styrene-isobutylene block copolymers or styrene-isoprene block copolymers and an ethylene-alpha-olefin copolymer or a polyolefin composition comprising 20-50 parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100. The styrene-isobutylene block copolymer is preferably SIBSTAR®. The styrene-isoprene block copolymers is preferably Hybrar® These compositions provide a soft touch feel due to low hardness values, good gas barrier properties, durability against heat and weathering and excellent vibration damping properties. More preferred is a composition comprising styrene-isobutylene block copolymers or styrene-isoprene block copolymers, an ethylene-alpha-olefin copolymer or a polyolefin composition comprising 20-50 parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100 and SBS or SEBS.

The present invention also relates to a composition comprising a styrene-isobutylene block copolymer or styrene-isoprene block copolymer and SBS or SEBS. These compositions show improved oil absorption. The compositions are preferably used in hockey fields, rugby fields or tennis fields.

The invention will be illustrated by the following examples without being restricted thereto.

Ball rebound is determined by an iron ball, which is dropped from a fixed height, and it was observed how many time the ball was height rebounding on a 6 mm injection moulded plaque.

Energy restitution is determined according to FIFA Quality Concept Handbook for test methods for football turf, March, 2006 Appendix A 4 “determination of dynamic response-new testing apparatus”, paragraph A 4.6.2.

Example 1

A granulate of a compound comprising SIBSTAR^R 102 T, a polyolefin, filler, oil, UV stabilizer and pigment was used as infill material in an artificial turf system. The ball rebound was measured and compared to Terra XPS^R, which is a thermoplastic elastomer comprising SEBS, a polyolefin, filler, oil, UV stabilizer and pigment and which is commercially available from DSM.

The ball rebound was classified from 0-5:

The results are shown in table 1. From table 1 it is clear that the use of the SIBSTAR^R 102T compound results in a reduction of height rebound of approx of 20-30% and total 2 rebounds if compared with Terra XPS^R.

Example 2

A granulate of a compound comprising HYBRAR^R 2, a polyolefin, filler, oil, UV stabilizer and pigment was used as infill material in an artificial turf system, the ball rebound was measured and compared to Terra XPS^R.

The results are shown in table 1.

From table 1 it is clear that the use of the compound comprising HYBRAR^R 2 results in a reduction of height rebound of approx of 20-30% and total 2 rebounds if compared with Terra XPS^R.

Table 1

Lab Trial	Compound of Terra XPS	Example 1 Compound SIBSTAR 102T	Example 2 Compound HYBRAR 2
Hardness Shore A (3 sec) ASTM D2240	52	57	59
Tensile Strength (Mpa) ASTM D 412-C	1,9	1,1	1,3
Elongation @ break, (%)ASTM 412-C	586	370	480
Tensile Modulus (100%) ASTM D 412-C	1,1	1,2	1,3
Tensile Modulus (300%) ASTM D 412-C	1,7	1,1	1,2
Tear Strength ASTM D 624-C	16	12,3	13,6
Specific Gravity (g/cm^3)	1,47	1,49	1,51
Abrasion Resistance ISO 1431 A	871	698	613
Iron Ball Rebound	0	3	3
Energy restitution	49		43

Iron ball rebound classified from 0-5:

- **0** is equivalent to standard product,
- **1** small reduction in height rebound and reduction of the number of rebounds,
- **3** reduction of height rebound approx of 20/30% and total 2 rebounds
- **5** no rebounds.

CLAIMS

1. Use of styrene-isobutylene block copolymers or styrene-isoprene block copolymers as infill material in artificial turf systems.
2. Use of styrene-isobutylene block copolymers according to claim 1 characterised in that the styrene-isobutylene block copolymers comprise 70-85-wt% p-isobutylene based on the total weight of the styrene-isobutylene block copolymer.
3. Use of styrene-isoprene block copolymers according to claim 1 characterised in that the styrene-isoprene block co polymers is a triblock copolymer which comprises polystyrene blocks and polyisoprene or vinyl-polyisoprene blocks.
4. Use of styrene-isobutylene block copolymers or styrene-isoprene block polymers according to any one of the claims 1-3 characterized in that the styrene-isobutylene block copolymers or styrene-isoprene block polymers further comprise a polyolefin and/or a styrene based thermoplastic elastomer.
5. Use of styrene-isobutylene block copolymers or styrene-isoprene block polymers according to claim 4 characterised in that the content styrene-isobutylene block copolymers or styrene-isoprene block polymers and polyolefin and/or styrene based thermoplastic elastomer is chosen in that way that the hardness varies between 40 and 90 Shore A.
6. Use of styrene-isobutylene block copolymers or styrene-isoprene block polymers according to any one of claims 4 or 5 characterized in that the polyolefin is an ethylene-alpha-olefin copolymer.
7. Use of styrene-isobutylene block copolymers or styrene-isoprene block polymers according to any one of claims 4 or 5 characterized in that the styrene based thermoplastic elastomer is SBS or SEBS.
8. Use of styrene-isobutylene block copolymers or styrene-isoprene block polymers according to any one of claims 4 or 5 characterized in that the polyolefin is a polyolefin composition comprising 20-50parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100.
9. Composition comprising a styrene-isobutylene block copolymer or styrene-isoprene block polymers, a polyolefin and/or a styrene based thermoplastic elastomer.
10. Composition according to claim 9 characterized in that the polyolefin is chosen

from an ethylene-alpha-olefin copolymer or a polyolefin composition comprising 20-50 parts by weight of a crystalline polyolefin and 50-80 parts by weight of an elastomer whereby the total parts by weight is 100.

11. Composition according to any one of claims 9 or 10 characterized in that the styrene based thermoplastic elastomer is chosen from SBS or SEBS.

12. Use of the composition according to any one of the claims 9-11 in soccer fields, hockey fields, rugby fields or tennis fields.

13. Use of the styrene-isobutylene block copolymers or styrene-isoprene block copolymers according to any one of the claims 1-8 as infill material in soccer fields, hockey fields, rugby fields or tennis fields.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/006070

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08J5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 2006/051952 A (BRIDGESTONE CORPORATION; MASHITA, NARUHIKO; OKADA, OSAMU; HIRAIWA, TOS) 18 May 2006 (2006-05-18) the whole document	1-13
X	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 12, 5 December 2003 (2003-12-05) & JP 2003 261760 A (ASAHI KASEI CORP), 19 September 2003 (2003-09-19) abstract	1-13
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2006	31/08/2006

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/006070

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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