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(54) Title: SELF-HEALING MATERIAL FOR VEHICLE TIRES

(57) Abstract: This disclosure relates to a polymer composition exhibiting self-healing and self-folding properties. The polymer composition is a polymer composite which may be augmented on the surface of the tire of the vehicle. The polymer composite may further include graphene, europium (II) as a rare-earth metal, a complex of polyurethane-thiourea-silica with disulphides, and an acrylic polymer.

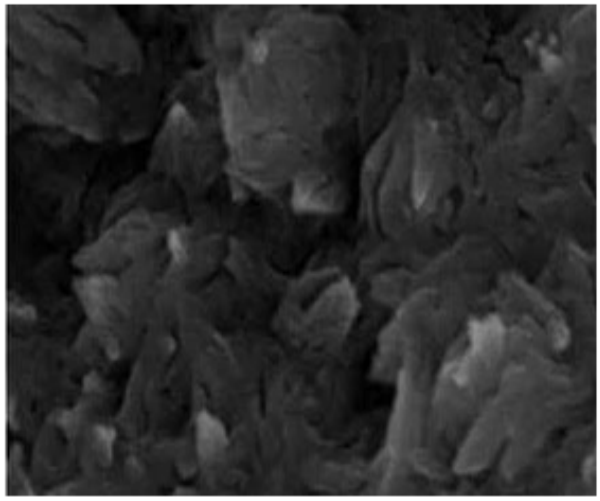

FIG. 1A

FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

SELF-HEALING MATERIAL FOR VEHICLE TIRES

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

Technical Field

[001] The present disclosure relates to a self-healing and self-folding kind of polymer material. More particularly, the invention relates to polymer material used in vehicle tires for safe travel through the vehicle on cold as well as hot terrains, and to the process of preparing such polymer material thereof.

Background

[002] Tires are subjected to one of the harshest environments experienced by any consumer. In some cases, tires may develop cracks in the tire rubber in these harsh environments. Such an exposure of tires to extreme climates and different terrains such as cold, snowy, hot, etc., can eventually cause rubber to lose some of its elasticity and allow surface crack to appear. These cracks typically develop in the sidewalls or at the base of the tread grooves. Cracking can be accelerated by too much exposure to heat, vehicle exhaust, ozone, and UV rays from the sun. Therefore, to avoid cracking or abrasion of tires, the manufacturers are providing spikes on the surface of the tires to allow the tires to move on different road terrain such as cold, hot, or snowy roads, and prevent vehicle from sliding on snow. These spikes are currently provided as metallic spikes which are integrated into tires. Due to metal the overcall cost of the tire goes high, and tires is costly. Also, metallic spikes can damage tires in physical and mechanical stress condition thereby, degrading driving and leaving the tire with no adhesion and anticorrosion properties.

[003] Therefore, in the present state of the art it is thus desirable to have a tire which may possess the ability to get self-repaired in the event of any crack, damage, wear, or tear, occurring to the polymeric structure of the tire, thereby maintaining strength and durability, and extending the life of the tire. Thus, there is a need to develop an ecofriendly tire which can rebound and self-heal itself while running on roads of uneven terrain and during changed weather conditions such as winter or summer, thereby preventing sliding of vehicles specially cars running on snowy roads.

Summary

[004] In a first aspect of the present invention, there is provided a polymer composition exhibiting self-healing and self-folding properties as well as characteristics. The polymer composition is a polymer composite which may be peppered on the surface of the tire of the vehicle. The polymer composite may further include graphene, europium (II) as a rare-earth metal, a complex of polyurethane-thiourea-silica with disulphides, and an acrylic polymer.

[005] In another aspect of the present invention there is disclosed a process for preparing a polymer complex involving the steps of mixing a component of polyurethane-thiourea with 50 wt.% aqueous silica to form a mixture of polyurethane-thiourea-silica. Adding to the mixture of polyurethane-thiourea-silica, graphene, 20 wt% europium (III) dipicolinic acid complex and stirring the mixture using a magnetic stirrer to form a composite of graphene, europium (II) polyurethane-thiourea-silica-with disulfides.

[006] In a further aspect of the present invention, it is disclosed that the polymer composite as provided are soft, nano-sized thermo-responsive spikes or fillers used as grippers for improving the grip of the tires when running on snowy roads. The self-healing polymer composite as disclosed is an autonomous composite which can memorize original shape of the tire when the vehicle is running on a cold or snowy surface.

[007] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

Brief Description of Drawing

[008] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, explains the disclosed principles.

[009] **FIG. 1** illustrates the scanning electron microscopic (SEM) images shown in three stages as (A) Unfolded stage (B) folded stage and (C) spikes surface.

[010] **FIG. 2** illustrates a graph depicting the effect of strain on folding angles.

[011] **FIG. 3** illustrates a graph depicting the effect of film thickness on folding angles.

[012] **FIG. 4** illustrates the SEM images of cracks on a surface shown in two stages as (A) and (B).

[013] **FIG.5** represents the spectral analysis of self-healing-sample at cracked and healed condition obtained by Fourier-transform infrared spectroscopy (FTIR).

Detailed Description

[014] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims.

[015] In an embodiment, a chemical compound of polymeric material casted in the form of a stud including the mixed composite of polyurethane-thiourea-silica-with disulphides is disclosed. The stud as disclosed herein, may be inferred as a type of a filler or a thorn or spikes which are to be used for layering on the tire to save the tire from any damage. The stud as deployed or augmented on the surface of the tire of a vehicle may expand or contract when subjected to change in temperature. In addition, surface of the tire of a vehicle may expand or contract when subjected to change in road terrain. Therefore, it is found that for safe movement and sustainable life of the tires, soft polymer grade materials should be used for preparing studs or spikes to be used on the tires.

[016] In an embodiment, a soft foldable hydrophobic acrylic rubber based polyacrylate elastomers are disclosed. The polyacrylate elastomer is be formed as a polymer of an acrylate monomer. The acrylate monomer may form an acrylate polymer which is commonly known as polyacrylate or an acrylic polymer. On such polyacrylate polymer of about 15mmx30mm size with a thickness of about 5 mm, there is provided a solution of gelatin polymers which was spin coated on the polyacrylate polymer with a rotating speed of about 600-1200 rpm, or preferably about 800 rpm, for 30 secs and at a temperature of about 20^{o}C to about 40^{o}C, more preferably at about 35^{o}C. The polymer solution spin coated on polyacrylate polymer may be dried under vacuum at a temperature of about 40^{o}C. These polyacrylate

polymers have excellent characteristics and properties such as high surface adhesion, elasticity, and resistance to breakage.

[017] The acrylate monomer as used in the context of the present invention may be selected from, but not limited to a group comprising of methacrylate, methyl methacrylate, ethyl methacrylate, 2-hydroxyethyl methacrylate-co-acrylic acid, poly(ethylene glycol dimethacrylate), poly(ethylene glycol methacrylate), poly(ethylene glycol methacrylate)-co-poly(ethylene glycol dimethacrylate), chitosan poly(ethylene glycol methacrylate), chitosan poly(ethylene glycol dimethacrylate), chitosan poly(ethylene glycol methacrylate)-co-poly(ethylene glycol dimethacrylate), diethylaminoethyl methacrylate, glycidyl methacrylate, poly(methacrylic acid), and combination thereof.

[018] The gelatin polymer layer which is a second polymer layer coated on the polyacrylate polymer layer may be synthesized by performing polycondensation reaction of hexanediol dissolved in a suitable solvent such as tetrahydrofuran (THF) and/or fumaric acid mixed with THF and carrying out the polycondensation reaction at a temperature of about 20^{o}C to about 80^{o}C and more preferably, at a temperature of about 60^{o}C. The obtained gelatin polymer post polycondensation was then dried under vacuum conditions for a period of about 20 hours to obtain a solid gelatin polymer. The solid gelatin polymer was further washed using another washed solvent such as chloroform ($CHCl_3$) commonly known as trichloromethane. The unwanted or excessive polymer post polycondensation reaction was washed using dichloromethane or trichloromethane solvent in an amount of about 30 ml. It should be noted that the amount of solvent to be used for washing the polymer is proportionate to the amount of polymer to be washed. For example, for 500 mg of obtained polymer to be washed there would be required merely 10 ml of trichloromethane. Then 100 µl of 2-(Dimethylamino)ethyl methacrylate (DMAEMA) and 50 mg of polymer was added to the keptopicinic solution.

[019] A “suitable solvent” as used in the context of the present invention refers to a solvent selected from, but not limited to, the group of alcohols, hydrocarbons, halogenated solvents, esters, ethers, ketones, sulfoxides, formamide, amides, nitriles, pyrrolidines, carbonates, water and the like. Specifically, the suitable solvent as used in the present invention is selected from, but not limited to, tetrahydrofuran, toluene, o/m/p-xylene, 1,4- dioxane, dichloromethane, carbon tetrachloride, dichloroethane, dichlorobenzene, chlorobenzene, methanol, ethanol, isopropyl alcohol, acetonitrile, ethyl acetate, acetone, methyl ethyl ketone, 2-methyl tetrahydrofuran, butyl acetate, isobutyl acetate, t-butyl acetate, propyl acetate, propylene acetate, butanol, t-butanol, methyl t-butyl ketone, dimethyl sulfoxide, N-methyl pyrrolidine, dimethyl acetamide, dimethyl formamide, N-methyl acetamide, acetamide,

acetone, methyl isobutyl ketone, acetonitrile, propionitrile, methyl ethyl ether, methyl tert-butyl ether, dimethyl ether, diethyl ether, cyclohexane, n-heptane, water and mixture thereof.

[020] In an embodiment, there is disclosed a process for synthesis and production of a polymer composite using the obtained polyacrylate polymer. The polymer composite is formed by first preparing a dispersion of polyurethane-thiourea (PUTU). PUTU in an amount of about 30 wt% is mixed in water with about 50 wt.% of an aqueous silica and about 20 wt% of Europium (II) dipicolinic acid, to form a polymer complex of europium (II) complex-polyurethane-thiourea-silica (PUTU-silica-europium). The mixture is stirred using a magnetic stirrer rotating at a speed of about 800 rpm (revolutions per minute), for approximately 30 mins (minutes) to 120 mins, and at a suitable temperature, ranging from about 20^{o}C to about 80^{o}C. The mixture may be stirred preferably for 60 mins (1 hour) and at a preferable temperature of at least about 35^{o}C.

[021] In an embodiment, the obtained complex mixture after stirring is then passed for an ultrasonic bathing in a bath tank, whereby the ultrasonic bathing may occur in one or more cycles or batches. For example, the ultrasonic bathing occurring in cycles or batches may either occur in a single cycle or one batch or in two cycles or two batches such that one cycle or one batch would last for at least 25 mins. The ultrasonic bathing helps to form a homogeneous solution by increasing the solubility with the help of ultrasonic vibrations. The prepared composite of PUTU-silica-europium composite post bathing contains water, which is then dried and casted on Teflon plates to be formed in the shape of film and having the dry film thickness of up to 200 μm. The thin film of PUTU-silica-europium composite then undergoes a slow process of water evaporation by keeping the PUTU-silica-europium composite polymer at room temperature for up to 7 days, and then for 16 hours at a temperature of about 45^{o}C and then drying for 1.5 hour in a vacuum to a same temperature of about 45^{o}C, thereby transparent or very slightly opaque continuous films of graphene, europium (II) complex-polyurethane-thiourea-silica-with disulphides are formed.

[022] Further, the polymer films are formed in a ratio of 1:1:1. The complex polymer are further dipped coated with dimethyl formamide (DMF) solution for at least 10 mins and dried at a room temperature under vacuum condition for a duration of at least 24 hours. Since obtained foldable polymer complex film is not photo-cross linkable therefore the film is cut into at least 6 arms, in a shape of foldable fingers by using an infrared heating laser for cutting the film.

[023] In an exemplary embodiment, mechanical motion of self-fold polymer film is to be derived from the large and reversible shrinkage response of the formed polymer

composite film in varying thermal or pH environments. By using a varying pH environment self-folding properties of the polymeric film could be tested. It is to be noted that pH for Snowy roads is slightly acidic, and when the snow melts, the pH of the melted snow becomes neutral, and it also defines the snow depth. Although at a high pH, the snow depth is high and at a low pH, the snow depth decreases. This action is facilitated by the network structure of the polymer composite so formed and the capacity of the polymer composite for large strain. However, due to low modulus of the acrylate polymers as used in manufacturing the polymer composite, have a limited gripping ability on the task surface such as roads. Using experiments and modelling, we design, fabricate, and characterize self-folding nano-grippers polyacrylate polymers of thickness 5 nm.

[024] Further, it has been shown that an iron oxide (Fe2O3/gold) nanoparticle can be embedded into the porous polymers layer, allowing the nano-grippers to be responsive and remotely guided using magnetic fields/piezoelectric effects. Therefore, it has been investigated using finite element models, that the polymer layers possess the self-folding characteristics of the microgrippers.

[025] Referring now to FIG. 1, where it is illustrated how the operation and functionality of the formed polymer composite in the form of polymeric microgripper studs performs while moving on a snowy road. The soft nano sized polymer grippers are disclosed which are thermos-responsive and exhibits sequential folding of polymers due to the gradient shrinkage as per the change in road temperature. At cold temperature in presence of snow or ice, lotus petal shapes shrink and turn it into studs or grippers as like expanding and closing fingers of human. For the computational model, the folding of a fingers or grip of the arms was simulated using the finite element analysis (FEA) software Abaqus. This model simulated the complete process of microgripper folding triggered by pre-load initial strain. Dimensions used here were obtained using scanning electron microscope (SEM) images at 1mm magnification, (as depicted in FIG.1) were used for finite element simulation.

[026] Referring to FIG.1A which shows the SEM image of nano sized polymer grippers under unfolded stage when exposed to a warm condition or to a slightly higher temperature of more than at least 10^{o}C, or more than at least 20^{o}C, or more than at least 40^{o}C where the polymer gripper spikes become heated. Furthermore, it is illustrated in FIG.1B how the nano or micro sized polymer gripper shrinks, when exposed to freezing conditions having a temperature of less than about 0^{o}C, or at least about -10^{o}C. Thus, it is observed that at freezing conditions the polymer gripper shrink or get folded. Further, in FIG.1C it is shown how the

micro sized polymer grippers or nano sized polymer grippers may be folded with spikes on the surface of the tire when exposed to freezing conditions of about -10^{o}C.

[027] To further observe how the polymeric microgripper stud performs self-folding mechanism like folding of a finger grip of human arms, by studying the folding mechanism of the polymeric studs when deployed on the tires by simulating via the finite element analysis (FEA) software to provide the analysis of spikes based on polyacrylate polymers as provided in table 1 provided below. Thus, the polymer composite is stable and thermos-responsive at a temperature ranging from about -20 ^{o}C to about 60 ^{o}C as depicted in table 1.

Table 1

Sample	Temperature (^{o}C)	D (nm)	Tip to Tip diameter (nm)	Mid-arm to arm diameter (nm)	Bottom to bottom diameter (nm)	Folding angles
Polyacrylate spikes	40	5	5	5	5	0
	35	5	4.1	4	5	10
	25	5	3	3	5	50
	15	5	2.5	2.5	5	80
	5	5	1	2	5	100
	0	5	0.5	1.2	5	109
	-5	5	0.5	1.2	5	112
	-10	5	0.5	1.2	5	112
	-20	5	0.5	1.2	5	112

[028] In another embodiment of the present invention, there is provided a model based analysis of the microgripper polymer, wherein the strain can be monitored using the folding angles as illustrated in FIG.2. As per the model based analysis, strain can monitor the folding angles in a way the strain gets proportionate to the folding angle therefore as strain increases folding angle increases. Hence, the graph is linear and increasing. One larger mismatch is that the strain allows the gripper to fold more tightly. Thus, in a way the strain may be tuned by choosing different polymer materials, applying magnetic fields or piezoelectric field effects, and adjusting thin film deposition condition. This implies that film thickness is also a tunable property in gripper fabrication and affects the folding angle.

[029] Thus, it was found that due to larger bending stiffness, the folding angle decreases as film thickness increases (as measured by profilometer), hence the studs or spikes were developed by optimizing the film thickness up to a size of at least 5 nm as shown in FIG.3. The characterization of thin film thickness and gripper folding angle is thus shown in FIG.3.

[030] In an embodiment, the polyurethane-thiourea-silica with disulphides bonds exhibits excellent intrinsic self-healing properties. These intrinsic self-healing polymer materials exhibits fast self-healing of mechanism due to no diffusion and polymerization control steps. The polymeric materials are very much adaptable in restoring low-volume defect or cracks because of their very overly sensitive reversible dynamic bonds in molecular scale. It is noticeable that the shape memory of polymeric materials due to the amorphous structure and high package density of disulphides provides outstanding dynamic exchanging performance at room temperature, and much lower negative temperatures as well.

[031] The polymeric materials such as the polymer composite thus obtained possess excellent capability of memorizing the temporary shapes by entropy-driven process to autonomously reunite crack interfaces or in a way restore any damage caused at room temperature and negative temperature to the materials or to the vehicle tires when the polymeric material is augmented as spikes on the tires. Thus, the obtained polymeric complex material shows the great applicability for long-lasting tyers in vehicle applications at cold region as well as hot regions.

[032] In an exemplary embodiment, to further study the properties and performance of polymeric composite material surface images were captured by SEM at a magnification range of 1 mm to get experimental proof of cracks and self-healing properties of polymeric materials. Thus, it is observed that low volume cracks occur on the surface of the tires in colder regions where the temperature goes in negative to about -5^{o}C. However, by using the present polymeric composite provided on the surface of the spiked tires, the cracks begin to self-heal in a way to rebound the tire from the damaged state to normal state.

[033] This rebound is considered as self-healing mechanism caused due to the use of invented polymeric spike material. Also, the cracks begin to heal when the terrain or the condition starts to change from a negative temperature to a positive temperature such as temperature varying from -5^{o}C to 10^{o}C. It is an important aspect that the self-healing of the tire surface augmented with polymeric spike is due to H-bonding and di-sulphides exchange reactions occurring simultaneously and as soon as the tire contacts the road surface at different temperatures. The self-healing polymer composite may withhold a pressure of about 20 Psi to about 150 psi.

[034] In an embodiment, the self-repairing property is evaluated quantitatively by tensile testing employing repaired samples by the butt joint technique at the cut surface. The percentage of healing efficiency at different healing temperature were summarized in the Table 2.

Table 2

Healing Temperature	Film thickness	Max. Stress (%)	Healing efficiency%
45^{o}C	5 nm	0. 02032 ± 1.06	86.2
25^{o}C	5 nm	0. 02032 ± 1.06	83.5
15^{o}C	5 nm	0. 05014 ± 1.12	84.9
10^{o}C	5 nm	0. 1389 ± 1.32	84.3
0^{o}C	5 nm	0. 2367 ± 1.21	83.4
-15 ^{o}C	5 nm	0.3569 ± 1.45	86.4

[035] It is often found and seen that too much temperatures variation cause tire expansion and contraction which leads to premature cracking. In chilly winter, tires lose elasticity and get rigid. In sizzling summer, tires get expansion or dry-wall cracking. The polyurethane-thiourea-silica-with disulphides exhibit self-healing properties at cold temperature or in the presence of snow due to following unique functionalities:

[036] (1) the invented polymer composite crosslinked by chemical covalent interactions and abundant hydrogen bonds into a three-dimensional network with snow crystal that water crystals.

[037] (2) The invented composite shows excellent shape memory effect (property to get into original state or recover its shapes) by combined functionality of disulphides (exchange reactions), silica enhances the self-healing at snow due slightly acidic pH (3.65) which enhances the bonding (covalent/ionic) with snow crystals hydrogen bonds and silica.

[038] (3) The developed polyurethane-based composite is highly colourless and transparent, like some common polymer used in tires, such as polymethyl methacrylate, polycarbonate, and polystyrene This composite possesses a glass transition value of -26.5^{o} C. Therefore, it is extraordinarily strong and stiff (with a tensile Young Qs modulus as high as 1.6: 0.02 GPa) at room temperature, which can easily sustain a heavy load without any bending or cracking. Indeed, the weak but dense hydrogen bonds and ionic interactions are responsible for this excellent mechanical rigidity. Moreover, due to the elevated level of steric hindrance, due to composite structure that enables the wobbly or movable packing of adjacent urethane

moieties, the assembled hydrogen bonds are highly mobile after cleavage, even at temperatures below the glass transition temperature (Tg) and enhances the self-healing, which facilitates the reconfiguration of the damaged networks.

[039] In another exemplary embodiment, it is disclosed that the tensile test of each sample is to be done using Testometric M500-50CT Universal Testing Machine. As a working example it is further described that the samples were cut into standard dumbbell size. The load used in this test was 10kN with the speed of about 15mm per min (minute). The percentage of healing efficiency (Rσ) was obtained from the ratio of stress initial (σinitial) over stress healed (σhealed), according to American Society for Testing and Materials (ASTM D5045-99). Thus, the healing efficiency of polymer composite remains almost same 83-86%, reveals that invented polymer composite shows healing efficiency at ambient as well as cold temperature also due its intrinsic self-healing properties as well as shape memory effects were molecular movements feasible at cold temperature due to lose density of bonding in the network.

[040] Further, to study the characteristics of the polymer composite material Fourier-transform infrared spectroscopy (FTIR) spectral analysis of self-healing was performed. The spectral comparative analysis at cracked and healed samples was performed as shown in FIG. 5. The retention of all the functional peaks at original, cracks and self -healing (at -10^{o}C) confirms the no change in functional and nanostructure of invented film.

[041] The three curves as shown in FIG. 5, on the FTIR spectra graph are to be interpreted to depict the following: curve (A) shows polyurethane-thiourea-silica with disulphides bonds formed before cracks at a temperature of about 45^{o}C, secondly in curve (B) it is seen that polyurethane-thiourea-silica with disulphides bonds when cracked at a temperature of about -10^{o}C, thirdly in curve (c) it is seen that polyurethane-thiourea-silica with disulphides bonds after self-healing at negative temperature of about -10^{o}C, and the wavenumber varies from about 4000 cm^{-1} to about 500 cm^{-1}.

[042] Referring now to FIG. 5, the bands located at 3450 cm−1 corresponds to the N−H stretching vibration and the band at 1540 cm−1 is assigned to the N–H in-plane bending vibration. The absorption bands at 1560 and 1380 cm−1 are assigned to the –CH2– bending vibrations. The bands at 2985 and 3005 cm−1 are associated with the C–H asymmetry and symmetric stretching vibration of methylene in polyurethane molecular chain. The characteristic band about 1720 and 1651 cm−1 is related with nonhydrogen bond C=O hydrogen bond C=O in urea, respectively. This polymer composite has a characteristic absorption peak of SS bond at 650. The retention of all characteristics curve at wide

temperature range and cracks/self-healing process concludes the excellent shape memory effect of polymer composite and fast healing mechanism at wide temperature range.

[043] Furthermore, the three curves A, B, and C of FIG. 5 are in line with the characteristic peaks of cracks and self-healing properties of Polyurethane-thiourea-silica with disulphides bonds. Although it is not shown how the cracks looks like when they are formed by uneven road terrain or during change in weather condition or due to snowy roads, still the cracks that are formed are originally deep and wide, then slowly due to the self-healing mechanism of the polymeric material the crack resumes and gets completely healed. However, due to the unique remembrance of the invented polymeric complex material about original shape, the polymeric material helps rebound the cracked surface.

[044] As will be appreciated by those skilled in the art, the techniques described in the various embodiments discussed above are not routine, or conventional, or well understood in the art. Considering the above-mentioned advantages and the technical advancements provided by the disclosed method and system, the claimed steps as discussed above are not routine, conventional, or well understood in the art, as the claimed steps enable the following solutions to the existing problems in conventional technologies. Further, the claimed steps clearly bring an improvement in the functioning of the device itself as the claimed steps provide a technical solution to a technical problem.

[045] The specification has described a self-healing polymer composite material and the process for preparing such polymer composites. The illustrated steps are set out to explain the exemplary embodiments shown, and it should be anticipated that ongoing technological development will change the way particular functions are performed. These examples are presented herein for purposes of illustration, and not limitation. Further, the boundaries of the functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternative boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed. Alternatives (including equivalents, extensions, variations, deviations, etc., of those described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternatives fall within the scope and spirit of the disclosed embodiments.

[046] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

WE CLAIM:

1. A self-healing polymer composite peppered on a vehicle tire, comprising:

graphene component;

europium (II) as a rare-earth metal component;

a complex of polyurethane-thiourea-silica with disulphides; and

an acrylic polymer.

2. The self-healing polymer composite as claimed in claim 1, wherein the polymer composite is prepared as a filler deployed on a surface of the vehicle tire.

3. The self-healing polymer composite as claimed in claim 1, wherein the complex of polyurethane-thiourea-silica with disulphides possess self-healing properties and memorizes original shape of its own based on entropy.

4. The self-healing polymer composite as claimed in claim 1, wherein the acrylic polymer is formed by polymerizing one or more acryl group monomer selected from methacrylate, methyl methacrylate, ethyl methacrylate, 2-hydroxyethyl methacrylate-co-acrylic acid, poly(ethylene glycol dimethacrylate), poly(ethylene glycol methacrylate), poly(ethylene glycol methacrylate)-co-poly(ethylene glycol dimethacrylate), chitosan poly(ethylene glycol methacrylate), chitosan poly(ethylene glycol dimethacrylate), chitosan poly(ethylene glycol methacrylate)-co-poly(ethylene glycol dimethacrylate), diethylaminoethyl methacrylate, glycidyl methacrylate, poly(methacrylic acid), and combination thereof.

5. The self-healing polymer composite as claimed in claim 1, wherein the acrylic polymer having a surface overlayed with a thin layer of a gelatin polymer, wherein the gelatin polymer imparts stretchability characteristics to said self-healing polymer composite.

6. The self-healing polymer composite as clamed in claim 1, wherein the acrylic polymer further comprises a polyacrylate based elastomer having self-folding, elastic, and hydrophobic properties.

7. The self-healing polymer composite as claimed in claim 6, wherein the polyacrylate based elastomer is an acrylic rubber composite.

8. A process for preparing a polymer complex comprising:

mixing a component of polyurethane-thiourea with 50 wt% aqueous silica to form a mixture of polyurethane-thiourea-silica;

adding to the mixture of polyurethane-thiourea-silica, graphene, 20 wt% europium (II) dipicolinic acid complex and stirring the mixture using a magnetic stirrer to form a composite of graphene, europium (II) polyurethane-thiourea-silica-with disulfides;

evaporating excess water from the formed composite of graphene, europium (II) polyurethane-thiourea-silica-with disulphides to form a dried composite of graphene, europium (II) polyurethane-thiourea-silica-with disulphides.

9. The process as claimed in claim 8, further comprises using the dried composite of polyurethane-thiourea-silica-with disulphides for the preparation of a self-healing and self-folding polymer composite.

10. The process as claimed in claim 8, further comprises dip coating the dried composite of graphene, europium (II) polyurethane-thiourea-silica-with disulphides, in a solvent comprising dimethyl formamide.

Dated this 15th day of December 2022

-- Digitally Signed--
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ABSTRACT

SELF-HEALING MATERIAL FOR VEHICLE TIRES

This disclosure relates to a polymer composition exhibiting self-healing and self-folding properties. The polymer composition is a polymer composite which may be augmented on the surface of the tire of the vehicle. The polymer composite may further include graphene, europium (II) as a rare-earth metal, a complex of polyurethane-thiourea-silica with disulphides, and an acrylic polymer.

[To be published with FIG. 5]

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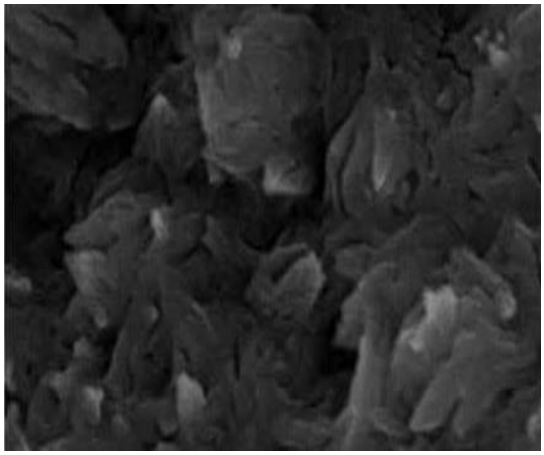

FIG. 1A

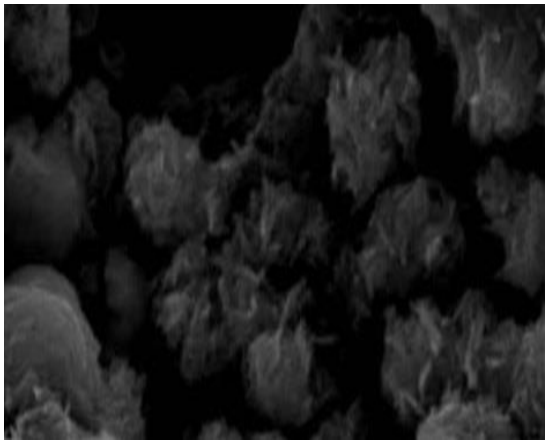

FIG. 1B

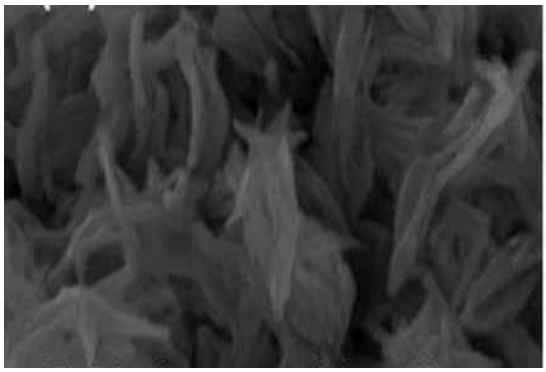

FIG. 1C

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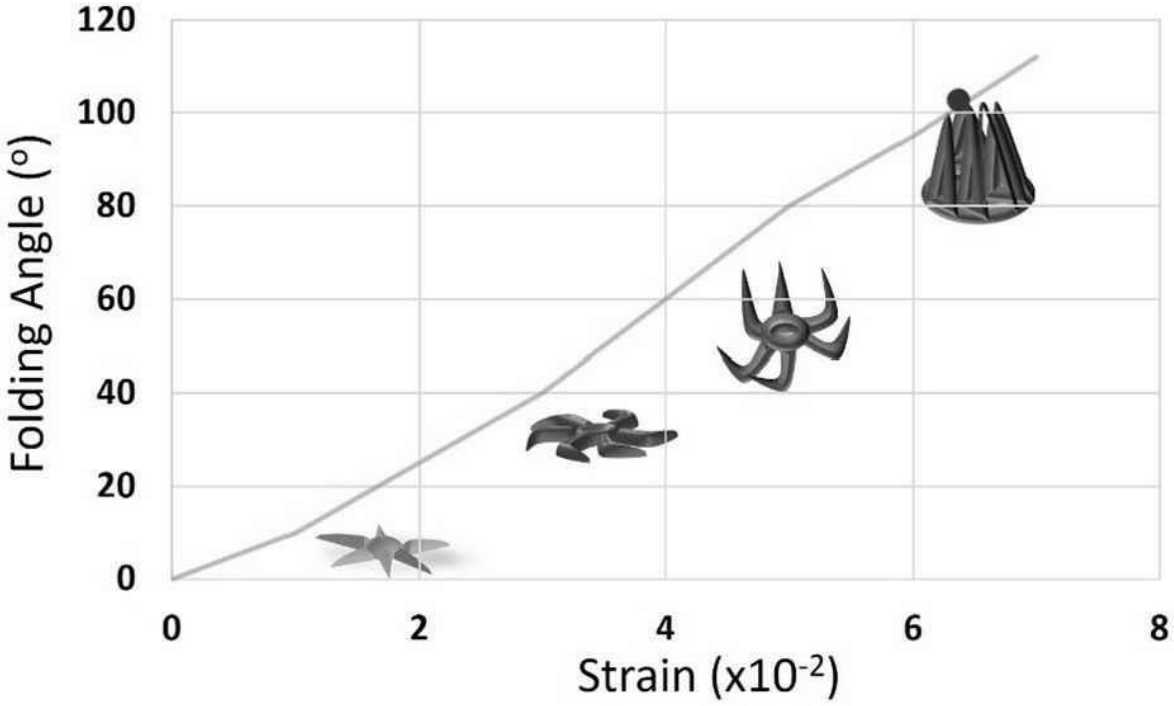

FIG. 2

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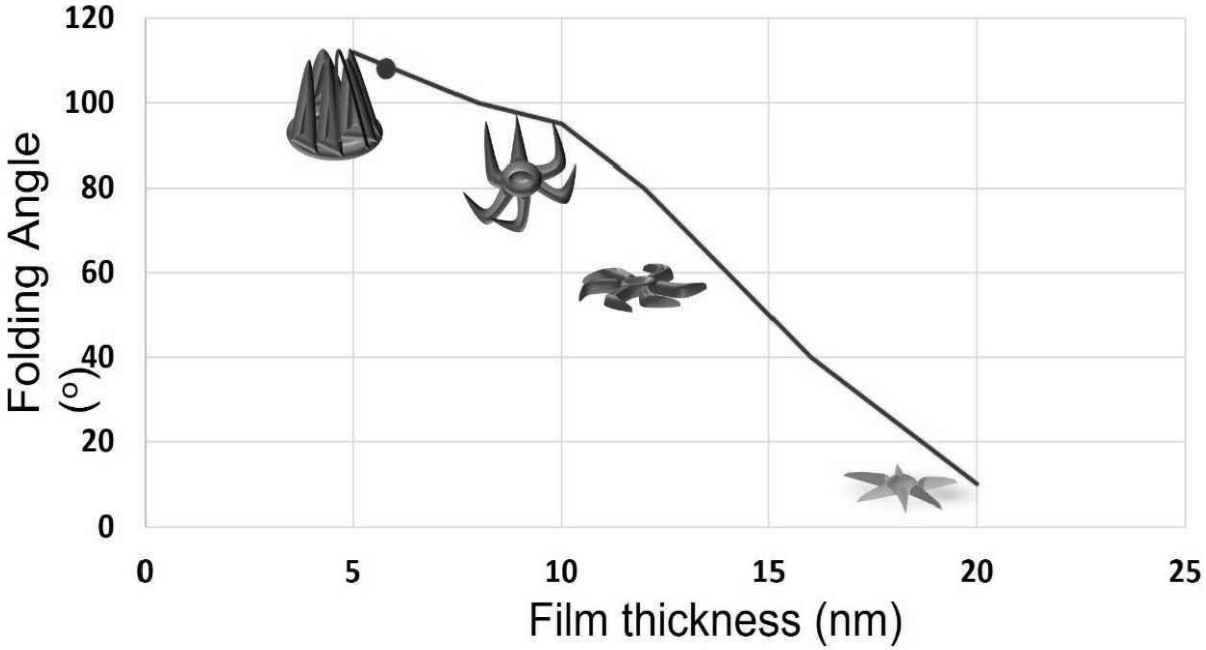

FIG. 3

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FIG. 4A

FIG. 4B

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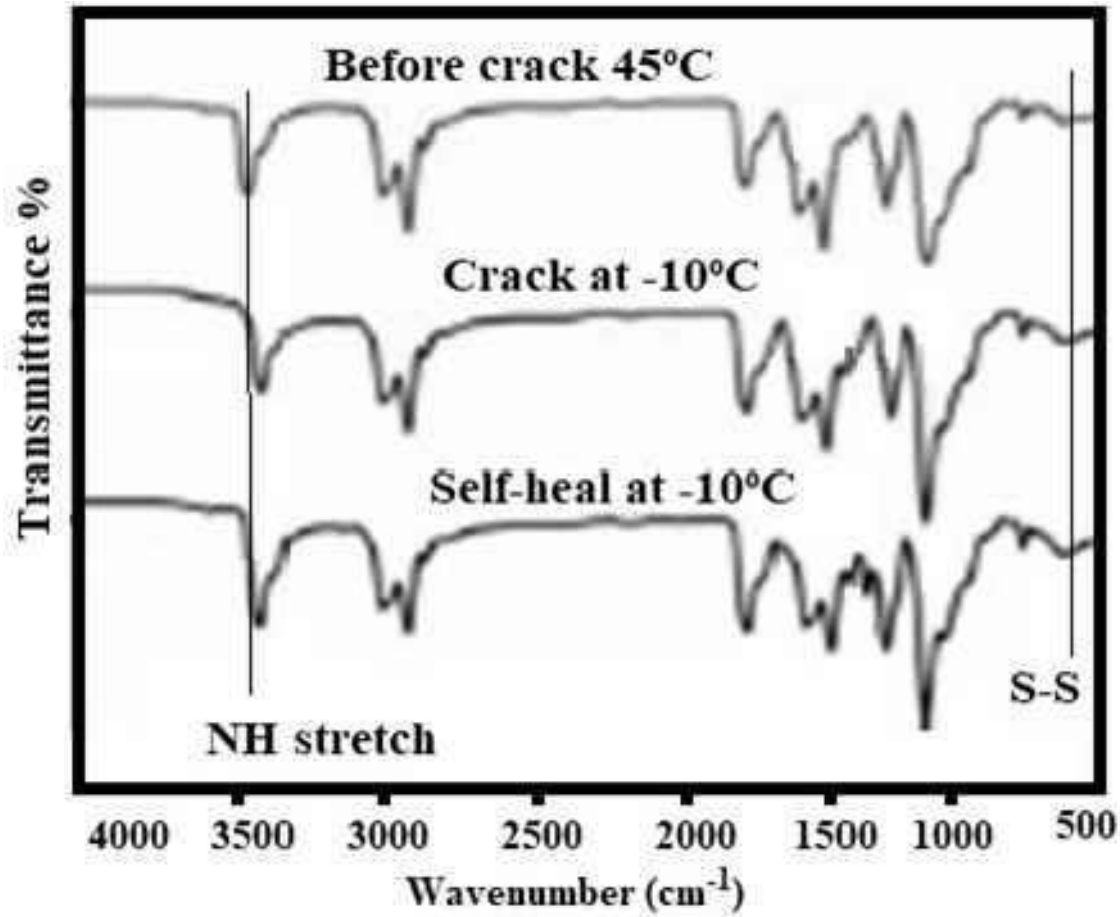

FIG. 5

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