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(54) **SPORTING OBJECT WITH VISIBLE TEMPERATURE SENSITIVITY**

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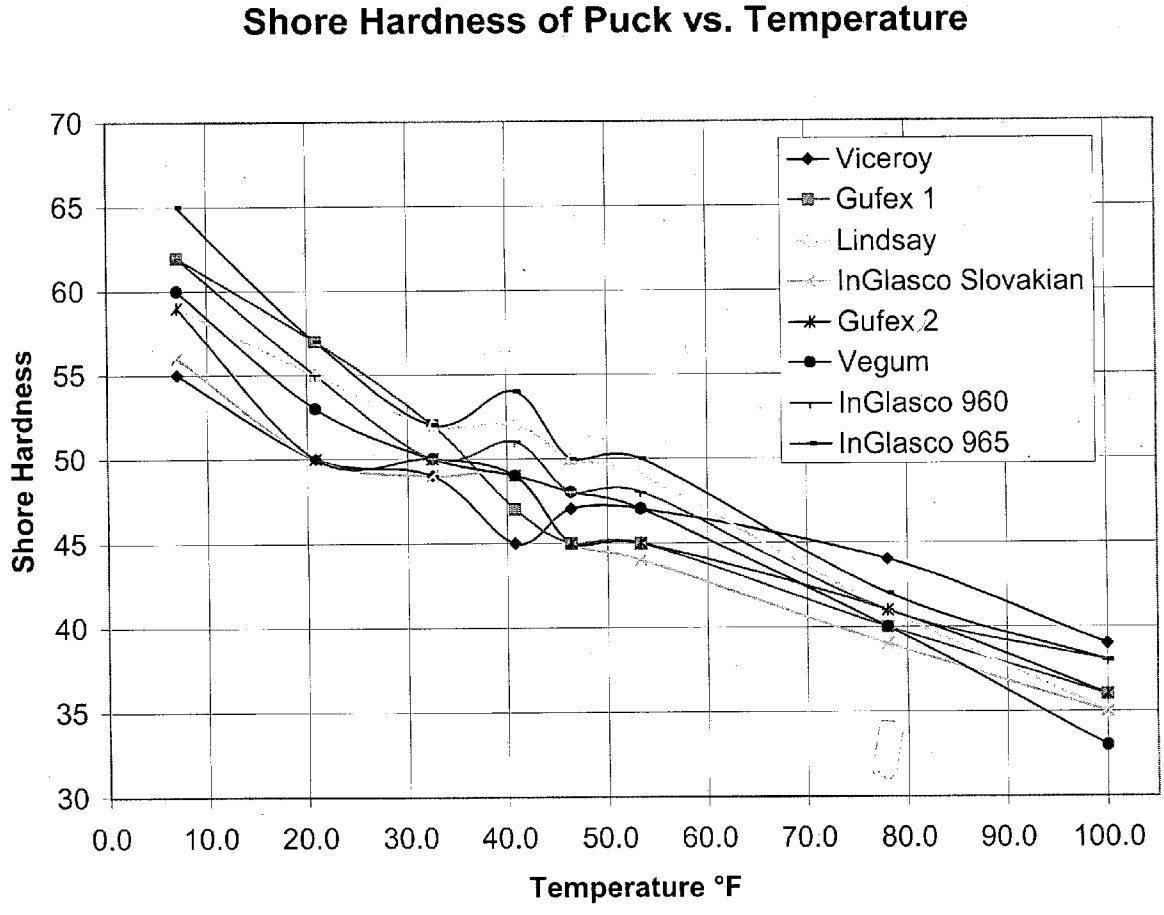
(57) **ABSTRACT**

An improved puck has a structural material in the general shape of a disk and a thermochromic visualization agent associated with the disk. Generally, at least a portion of the visualization agent is visually observable. The visualization agent generally can be, for example, incorporated into the material of the puck or applied as a coating onto the surface of the puck. Methods for playing a sporting activity can comprise evaluating an object used in the sporting activity to determine if the object is at a suitable temperature for playing.



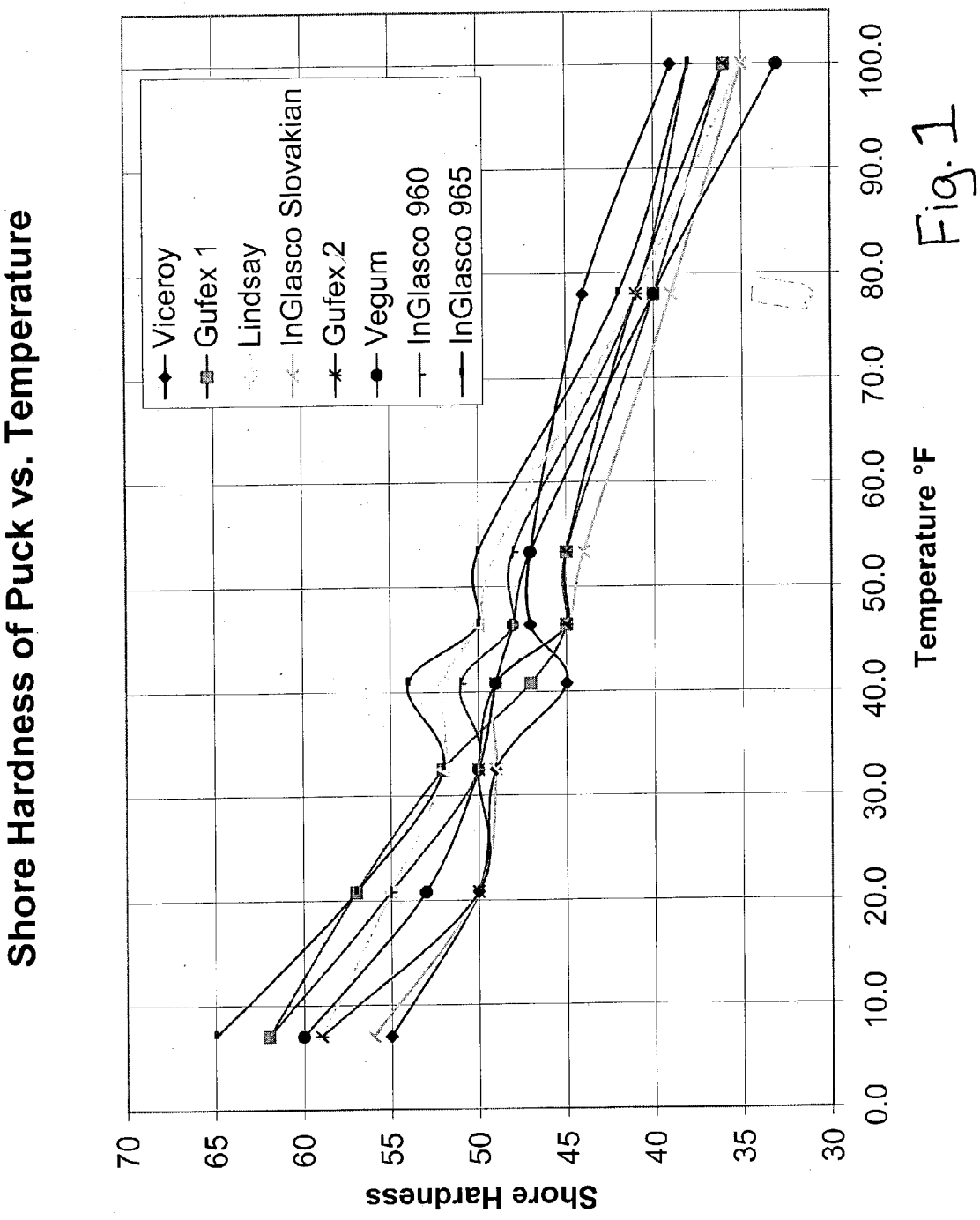

Shore Hardness of Puck vs. Temperature
Viceroy
Gufex 1
Lindsay
InGlasco Slovakian
Gufex.2
Vegum
InGlasco 960
InGlasco 965
Shore Hardness
70
65
60
55
50
45
40
35
30
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Temperature °F

Fig. 1

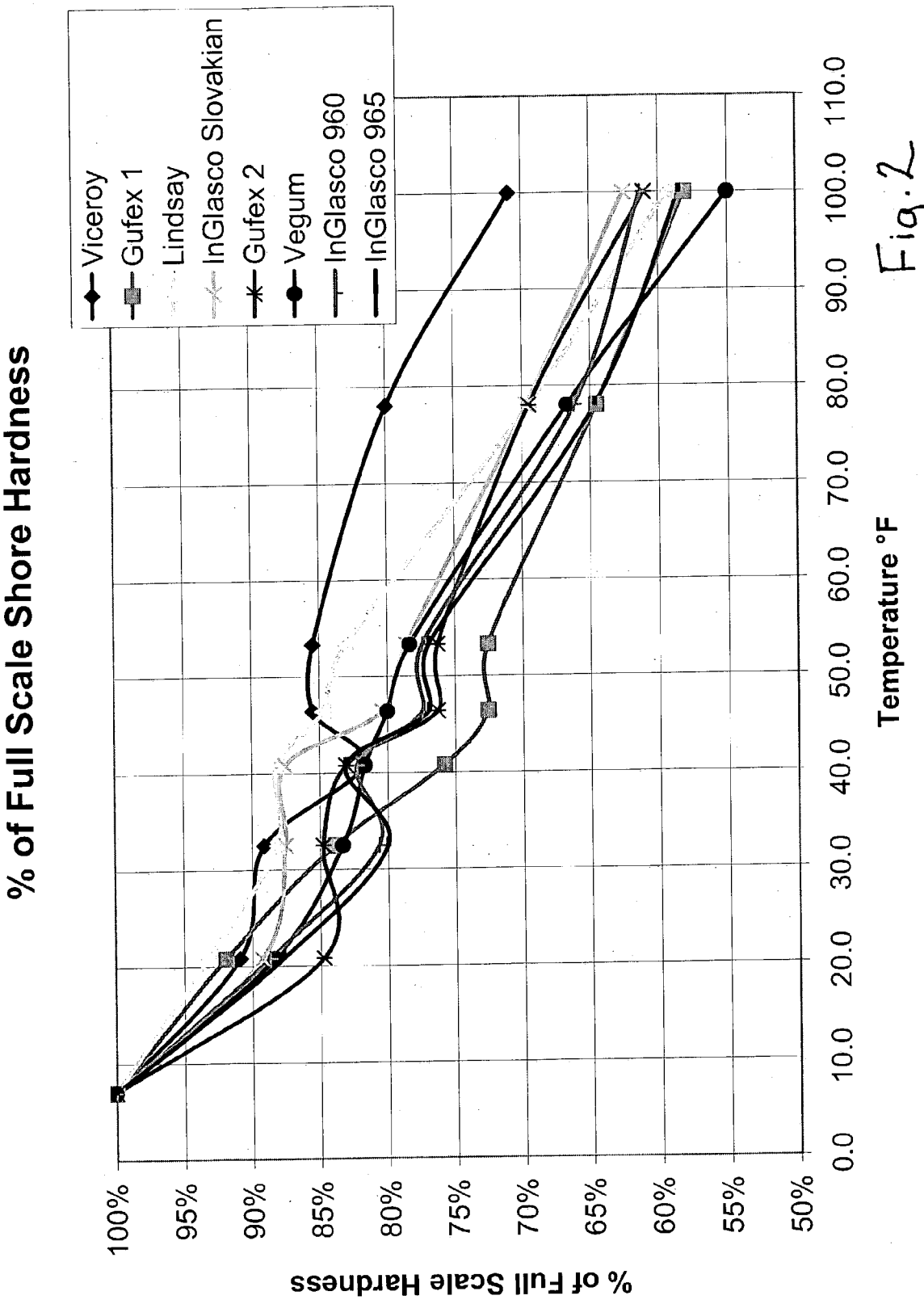

% of Full Scale Shore Hardness
Viceroy
Gufex 1
Lindsay
InGlasco Slovakian
Gufex 2
Vegum
InGlasco 960
InGlasco 965
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
% of Full Scale Hardness
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
Temperature °F

Fig. 2

SPORTING OBJECT WITH VISIBLE TEMPERATURE SENSITIVITY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Serial Number 60/380,589 to Summerfield filed on May 15, 2002, entitled "Hockey Puck With Visual Temperature Sensitivity," incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention generally relates to a sporting object that undergoes a visible change with a change in temperature, and the method of making the sporting object. More particularly, the invention relates to a sporting object, such as a disk or a ball that comprises a temperature sensitive composition that undergoes a change in color or opaqueness upon a particular change in the object's temperature. The temperature sensitive paint or ink can be, for example, applied to the exterior of the sporting object or blended with the material of which the sporting object is made.

BACKGROUND OF THE INVENTION

[0003] Various activities require the use of a sporting object, such as a disk or a ball, to engage in the activity. The physical properties of the sporting object can be of significance in effectively playing the activity. An ice hockey puck is of particular interest, where the hardness of the puck can affect the character of play. The use of a hockey puck on ice has been in existence for well over 100 years. Other sports based on objects such as balls, pucks and the like may experience temperature dependent performance of the object.

[0004] Today, ice hockey is played both at indoor and outdoor rinks. The outside conditions at which hockey is practiced or played vary a great deal in temperature and other conditions. Indoor conditions can vary also, but not generally to the degree that outside conditions vary. Outside rink conditions are obviously not controlled but the condition of indoor ice can be more controllable.

[0005] Two of the main factors that affect the performance and use of a hockey puck are the temperature of the ice and the temperature of the puck. The temperature of the puck is controlled in some cases by the procedure of placing the puck(s) in an "ice box" to prepare a cold puck. This procedure of cold storage of the pucks is almost always the practice at the professional and college level of hockey and, in many cases, is practiced at the high school and other lower levels of hockey. However, it would be useful in the play of hockey to know the general temperature of the hockey puck, as the temperature of the puck can affect the play of the game.

SUMMARY OF THE INVENTION

[0006] In a first aspect, the invention pertains to a puck comprising a structural material in the general shape of a disk and a first thermochromic visualization agent associated with the disk. Generally, at least a portion of the thermochromic visualization agent is visually observable.

[0007] In a further aspect, the invention pertains to a method for forming a puck with a temperature dependent visual appearance. The method comprises associating a thermochromic visualization agent with a generally disk shaped structural material.

[0008] In another aspect, the invention pertains to a method for playing a sporting activity with an object comprising a thermochromic visualization agent. The method comprises evaluating the object by visual inspection to determine if the object is at a suitable temperature for playing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **FIG. 1** is a plot of the shore hardness of seven commercially available ice hockey pucks as it varies with temperature.

[0010] **FIG. 2** is a plot of the percent of full scale shore hardness of seven commercially available pucks as it varies with temperature.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Improved embodiments of a sporting object change color or opaqueness dependent upon the temperature to which the sporting object is subjected. The sporting object can be, for example, a disk, a ball (which may or may not be generally spherical) or the like. The visualization of a change in temperature of the sporting object can allow the player(s) to determine if the sporting object is ready for play or, alternatively, if play needs to be adjusted to compensate for the change in performance of the sporting object due to the temperature of the sporting object. The adjustment in play can take the form of, for example, changing the strength involved to strike the sporting object, changing the angle of lift when striking the sporting object, replacing the sporting object with another that is at an appropriate temperature and/or the like. Herein, the reference to temperature dependent color changing also includes differences in opaqueness that can occur at different temperatures.

[0012] Temperature sensitive materials (i.e., thermochromic materials) that have different colors at different temperatures have been used in toys for amusement purposes. However, temperature dependent color or opaqueness-changing materials have not been suggested for use in evaluating the readiness for use or evaluating potential performance of a sporting object. The sporting object may be made from one or more materials such as rubber, synthetic polymers, fabric, animal products, such as leather or bone, stones, wood and the like. Although the following description focuses on the use of temperature sensitive materials associated with hockey pucks, other sporting objects can effectively use temperature sensitive color changing materials for the evaluation of the performance of the object.

[0013] Many ice hockey players and coaches keep the hockey gear inside during the winter months, at room temperature. This is typically done to keep the clothing warm in the winter months of the Northern Hemisphere. Because the hockey pucks may be kept in the same bag as the other gear, the pucks are inadvertently kept warm also.

Because of this, the hockey pucks can be much warmer than an appropriate temperature for desired performance during their use. During the spring and summer months of the Northern Hemisphere, the pucks will remain warm even if they are kept outside.

[0014] In some embodiments, the desired performance of a hockey puck is obtained when the puck is cold. In particular, the performance of the puck is within a desired range when the puck has a temperature within a particular range. Since ice hockey pucks are used on ice, the desired temperature ranges generally are relatively cold. Thus, pucks can be stored in an "ice box" prior to use. The hardness of a puck can be significant with respect to both shooting the puck and in passing the puck along the ice. It is desired to have a puck that is hard when shooting so that the puck is not particularly elastic. A warm puck bounces more. It is not desirable to have the puck bounce significantly, for example, after striking the boards. Furthermore, if the puck has undesirable bounce, the puck may be more likely to bounce into the crowd, which can decrease the safety of viewers of a hockey game. Thus, the temperature of the puck can be significant to the game of ice hockey. For pucks and balls used for in-line skate hockey, street hockey and the like, the desired temperature of the puck/ball may be different, and the thermochromic ink can be accordingly selected.

[0015] The temperature of the hockey puck relates directly to many of its physical properties, such as but not limited to hardness and coefficient of friction. This relationship of puck hardness and temperature is demonstrated for seven different commercially available hockey pucks in **FIG. 1** and **FIG. 2**. The graphs show how the hardness of the puck varies with the temperature of the puck. The pucks were tested for hardness using a type D Durometer at various temperatures. The graphs can be used to select the temperature ranges where the pucks' hardness would provide for a desired level of hardness and therefore improved play as related to shooting and passing the puck and rebounding the puck off the boards.

[0016] Thus, having a hockey puck in which the temperature can be determined by visual observation can greatly facilitate evaluation of puck temperature and corresponding desired puck performance. This visible manifestation can give an indication of the temperature of the hockey puck to the user of the puck. This visible change can then provide to the user of the puck an indication as to whether or not the puck is "ready" to be played with; i.e. the puck has its desired physical characteristics due to its temperature.

[0017] In contrast, an alternative approach to determine the readiness of the puck is to touch the puck to determine the temperature of the puck. This method of indicating readiness is not very reliable and can vary from person to person with respect to accuracy. Also, in using a touch indication of temperature, one would have to physically pick-up the puck, as opposed to simply looking at it.

[0018] As described herein, an improved puck provides a correlation of a visual manifestation in a sporting object, for example, a hockey puck, to sporting object's temperature. Generally, this correlation would be one physical appearance above a certain temperature and a second visible appearance below a certain temperature, although more than two manifestations of physical appearance can correlate with a corresponding plurality of ranges in temperature as well as a continuous change in visual manifestation with changes in the temperature. In various embodiments, the visual change between different temperatures in respective temperature ranges can be accomplished in many ways, such as a color change (e.g., yellow to red), a change from no color (e. g., black, white or clear) to a color, a change from a color to no color (e. g., black, white or clear) or a change in opaqueness. The color change can be reversible, such that the puck can be reused and can continue to provide the evaluative temperature dependent color change in the desired temperature range. In some embodiments, multiple colors can be used such that the colors or opaqueness may or may not change at the same temperature ranges.

[0019] While the thermochromic material can be applied to cause a visual change of the entire surface of the object, in some embodiments, only a portion of the objects surface may undergo a visual manifestation that is temperature dependent. In particular, it may be desirable for the temperature dependent visual manifestation to be in the form of a design. In some embodiments, the design can form a word or familiar pattern. Similarly, the use of multiple colors can allow different patterns or designs to appear on the surface of the hockey puck, dependent upon temperature. For example, at different temperature ranges different portions of a design or logo can appear, or alternatively, the entire design can appear over one temperature range. Other visual changes are also possible, and the visual change can be over the whole puck or any portion thereof.

[0020] In some embodiments, the hockey puck or a portion of the puck (or other sporting object) can be coated so that it changes in visual appearance at different temperatures. For example, a thermochromic polymer/ink can be used to generate the visual temperature sensitivity. Suitable thermochromic polymer/ink products include, for example, Chromicolor® products from Matsui International Co. Inc., Gardena, Calif. Suitable inks, paints and polymers are available in a range of standard colors as well as custom colors. In addition, the Chromicolor® inks are available in water-based inks, solvent-based self-curing inks, UV curable inks and epoxy two component inks. The epoxy inks and the UV curable inks are particularly durable. The screen printable commercial inks provide vivid colors. Stock versions of the inks have color transitions at particular temperatures, but custom versions of the commercial inks can have other selected temperatures for the color transition. Thermochromic compositions are described further, for example, in U.S. Pat. No. 4,717,710 to Shimizu et al., entitled "Thermochromic Compositions," incorporated herein by reference. Examples of other applications of thermochromic inks are described further, for example, in U.S. Pat. No. 5,085,607 to Shibahashi et al., entitled "Toy That Stably Exhibits Different Colors With Indicator For Proper Temperature Application," incorporated herein by reference.

[0021] In some embodiments, a base coat, such as a white layer, can be applied to the object's surface prior to the application of the thermochromic polymer/ink. The base coat can provide improved adhesion to the puck surface. Additionally, or alternatively, the base coat may also provide a contrasting color base onto which the thermochromic polymer/ink can be applied. The contrasting color can add to the design and/or improve visibility of the thermochromic

color. Also, the base coat can provide improved durability such that the thermochromic polymer/ink does not separate as readily from the puck substrate. Suitable base coat ink products include, for example, products in the Nazdar 9600 series screen inks from Nazdar, Shawnee, KS, which are available in durable epoxy-based or UV curable forms.

[0022] In another embodiment, the puck, with or without a base coat, can be coated with a thermochromic polymer/ink and then a translucent or effectively transparent topcoat can be applied on top of the thermochromic polymer/ink. The topcoat can provide improved durability to the thermochromic polymer/ink coating. It may be advantageous to add such a topcoat, due to the rough treatment the thermochromic composition may encounter as part of a sporting object such as a hockey puck. In a further embodiment, the thermochromic polymer/ink can be pre-applied onto a transparent film thus creating a decal or sticker and, subsequently, the decal or sticker can be applied to the hockey puck surface, for example with an adhesive, other curable polymer or the like. Additionally, after the decal has been applied to the surface of the puck/object, a translucent topcoat can be applied to protect the thermochromic polymer/ink.

[0023] In additional embodiments, the object can be formed from a thermochromic composition, or similarly the thermochromic composition can be blended with the material comprising all or a portion of the sporting object. A resulting thermochromic polymer can be used as part or all of the ingredients, for example, when the hockey puck or other sporting object is manufactured.

[0024] The thermochromic compositions can have different colors in a variety of temperature ranges. The surface of a hockey puck or other sports object can display one message or design in one temperature range and another in a different temperature range due to the different visual appearance of the thermochromic material at different temperatures. For example, the puck surface can display the word "bad" or an frowning face at one temperature range, and display "good" or "Cool Puck"™ or a smiling face in a different temperature range, generally a desired range for performing the sporting activity with the object. For example, a thermochromic ink can be white at a warmer temperature and blue or other color at a lower temperature, such that the appropriately cool puck has a visual design when ready for use in ice hockey.

[0025] In some embodiments, more than one thermochromic polymer/ink can be used on the surface of the hockey puck such that each thermochromic polymer/ink changes color at a different temperature transition. Both thermochromic polymers/inks can be present simultaneously on the same surface. In another embodiment, the thermochromic polymers/inks can change color in similar temperature ranges or alternatively, only one thermochromic polymer/ink can be used. In this embodiment, the thermochromic polymer/ink can be used, for example, to display a multi-color or single-color design or logo that appears in one temperature range.

[0026] The temperature range that the thermochromic polymer/ink changes color may be dependent on the use of the sporting object. In the example of a hockey puck, the thermochromic polymer/ink can be selected to change color in a temperature range below 30 degrees F. (−1.1 degree C.), in an additional embodiment the thermochromic polymer/ink changes color below 35 degrees F. (1.7 degrees C.), in another embodiment the thermochromic polymer/ink changes color below 40 degrees F. (4.4 degrees C.), and in a further embodiment the thermochromic polymer/ink changes color below 59 degrees F. (15 degrees C.). In further embodiments, the thermochromic polymer/ink may change color at temperature ranges above 70 degrees F. (21.1 degrees C.), in other embodiments the thermochromic polymer/ink changes color above 80 degrees F. (26.7 degrees C.), and in additional embodiments the thermochromic polymer/ink changes color above 87.8 degrees F. (31.0 degrees C.). A person of ordinary skill in the art will recognize that additional values of temperature for the color transition between these explicit values are contemplated and are within the present disclosure. To specify ranges for the particular visual transition, the visual appearance at one temperature can be references to a reference temperature, such as room temperature or other convenient temperature) different from the transition temperature.

[0027] A hockey puck generally has a disk shape with an outer diameter of about 3 inches (76.2 millimeters) and a height of about 1 inch (25.4 millimeters), although the dimensions can be varied as desired. The shape of the edge of the disk can be selected as desired, although for some uses the edge has a medium sharp knurl. A standard puck has a weight from about 155 grams to about 170 grams. A puck can be formed from hard rubber, such as vulcanized natural rubber or latex. Alternatively, a puck can be formed from synthetic polymers, such as polyvinyl chloride, polyisoprene, styrene-butadiene copolymers, arylonitrile-butadiene-styrene copolymer and the like, or mixtures thereof or from mixtures of natural rubber and synthetic polymers. Similarly, the thermochromic materials can be used with alternatively designed pucks, for example, as described in U.S. Pat. No. 5,695,420 to Bellehumeur, entitled "Hockey Puck," and U.S. Pat. No. 3,704,891 to Chiarelli, entitled "Puck For Ice Hockey," both of which are incorporated herein by reference. Variations in the puck shape with effectively the same performance properties of a hockey puck can be considered a generally disk shape.

[0028] The thermochromic polymer/ink can be mixed with the puck material during formation of the puck, such as molding or extrusion of the puck. Suitable molding approaches include, for example, compression molding, injection molding and blow molding, with compression molding and injection molding being of particular commercial interest. In compression molding, a charge of raw material can be put into a mold and then cured generally under pressure with heat applied. Once the item (e.g. a puck) is removed from the mold, any excess material can be trimmed, and then the item is ready for use. In injection molding, the raw material is forced through a runner via a screw conveyor and into the mold. After the material is cured, the molded item is removed, and any excess material is trimmed. Regardless which method is used, the amount of thermochromic material can be adjusted to yield the desired visual effect.

[0029] Alternatively or additionally, the thermochromic material can be coated or printed onto the exterior of the puck. Generally, a smaller amount of the thermochromic material can be used when applying the material as a coating rather than incorporating the thermochromic composition within the puck. Thus, an appropriate coating approach may

be particularly cost effective while being effective to product visually pleasing designs. Convenient approaches for applying a thermochromic design, for example, involves screen-printing of a thermochromic ink onto the puck, which can be placed onto a background ink. The desired pattern can be created in a layer over the screen such that the screen forms the desired image. A plurality of screens can be used to form a plurality of ink patterns, which may or may not be overlapping and with one or more involving a thermochromic material. Alternatively, the thermochromic polymer/ink may be applied via other means of painting or imprinting or via a pre-manufactured decal, for example, using approaches known in the art.

[0030] In use, the changing color of the puck can indicate to the player the readiness and relative hardness of the puck due to the temperature being within a desired range. For some sporting activities, the temperature dependent physical properties are a significant characteristic for the sporting activity. The visual change can be designed such that the player, referee and/or coach can readily see the visual appearance to evaluate the object, such as a puck.

[0031] The present invention has been described in terms of use with a hockey puck, however the invention is not restricted to this use. The invention may be embodied in other materials and forms (e.g. a ball) without departing from the spirit of any of the essential attributes of the invention. Additional uses for the invention will be recognized by those with skill in the art.

[0032] The embodiments described above are intended to be illustrative and not limiting. Additional embodiments are within the claims. Although the present invention has been described with reference to particular embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What we claim is:

1. A puck comprising a structural material in the general shape of a disk and a first thermochromic visualization agent associated with the disk, wherein at least a portion of the first thermochromic visualization agent is visually observable.

2. The puck of claim 1 wherein the first thermochromic visualization agent is incorporated into the structural material.

3. The puck of claim 1 wherein the first thermochromic visualization agent is coated onto at least a portion of the surface of the disk.

4. The puck of claim 3 further comprising a basecoat between the structural material and the first thermochromic visualization agent.

5. The puck of claim 1 wherein the first thermochromic visualization agent forms a pattern on the disk comprising letter.

6. The puck of claim 1 wherein the puck is an ice hockey puck.

7. The puck of claim 1 wherein the puck is an in-line skate puck.

8. The puck of claim 1 further comprising a transparent overcoat.

9. The puck of claim 1 wherein the first visualization agent has a different visual appearance at a temperature below about 59 degrees F. than at room temperature.

10. The puck of claim 1 wherein the first visualization agent has a different visual appearance at a temperature below about 35 degrees F. than at room temperature.

11. The puck of claim 1 wherein the first visualization agent has a different visual appearance at a temperature above about 88 degrees F. than at room temperature.

12. The puck of claim 1 wherein the structural material comprises cured rubber or a synthetic polymer.

13. The puck of claim 1 wherein the structural material comprises polyvinyl chloride, polyisoprene, styrene-butadiene copolymers, arylonitrile-butadiene-styrene copolymers and mixtures thereof

14. The puck of claim 1 further comprising a second thermochromic visualization agent.

15. The puck of claim 14 wherein the second visualization agent changes visual appearance at a different temperature from the first visualization agent.

16. The puck of claim 14 wherein the first visualization agent forms a first pattern on the disk and wherein the second visualization agent forms a second pattern on the disk with the second pattern being different from the first pattern.

17. A method for forming a puck with a temperature dependent visual appearance, the method comprising associating a thermochromic visualization agent with a generally disk shaped structural material.

18. The method of claim 17 wherein the thermochromic visualization agent is combined with at least a portion of the structural material prior to forming the disk shape to associate the thermochromic visualization agent with the structural material.

19. The method of claim 17 wherein the thermochromic visulaization agent is associated with the exterior of the disk shape.

20. The method of claim 19 wherein the thermochromic visualization agent is applied over a basecoat comprising an epoxy composition.

21. The method of claim 17 wherein the associating of the thermochromic material is performed by screen printing.

22. The method of claim 17 further comprising applying an overcoat over the thermochromic visualization agent.

23. A method for playing a sporting activity with an object comprising a thermochromic visualization agent, the method comprising evaluating the object by visual inspection to determine if the object is at a suitable temperature for playing.

24. The method of claim 23 wherein the object has a temperature dependent physical property and wherein the playing of the sporting activity is affected by the physical property.

25. The method of claim 24 wherein the physical property comprises hardness.

26. The method of claim 24 wherein the physical property comprises friction.

27. The method of claim 23 wherein the thermochromic visualization agent forms a pattern.

28. The method of claim 23 wherein the object has a general disk shape.

29. The method of claim 23 wherein the sporting activity is ice hockey.

30. The method of claim 23 wherein the object is a ball.

31. The method of claim 23 wherein the sporting activity is street hockey or in-line skate hockey.

32. The method of claim 23 further comprising playing the sporting activity after determining that the sporting object is within a desired temperature range.

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