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Characterization of 'natural' and 'high-quality' materials to improve perception of bio-plastics

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ABSTRACT

Over the past decade, the deployment of sustainable product design has led to a dramatic increase in the use of bio-plastics as an environmentally sensitive substitute to regular petroleum-based ones. Published literature has explored the environmental performance and their suitability as an alternative for regular plastics. However, the reception of these materials by users, who come into contact with these materials embodied in consumer products, has not been researched and published. Even though the principle of using such materials with improved environmental credentials is sound, it is down to the users' appreciation of those materials that ultimately determine their commercial success. A significant challenge faced by material developers and product designers is to facilitate the appraisal of bio-plastics as a natural alternative to regular plastics, whilst at the same time meeting users' perceptions of quality.

Drawing on the results of an empirical study this paper discusses when a material is perceived as 'natural' and/or 'high- quality'. The study concludes that there are more contradictory aspects than congruent aspects when evoking these two meanings. Imposition of new aesthetic values and uniqueness are discussed as critical strategies to elicit the desired meanings.

1. Introduction

Over the last decades, the role of plastics within the domain of product design has been fundamental to the progression of our man-made environment. Nevertheless, the appreciation of plastics, how they are received by users, has changed over time in different societies. When plastics first emerged, they stood for cheapness, low quality and in-authenticity (Sparke, 1990) and their tactile experience was generally unsatisfactory for people (Walker, 1989). Plastics were not brilliant, not heavy and not as hard as porcelain or iron. Clemenshaw in his book of Design in Plastics (1989) quoted Kenji Ekuan, a famous Japanese industrial designer, who explained that Japanese people had so entirely based their sensitivities upon the transience of time that they even reflect this approach to every aspect of their life, including materials: "*they feel not only uncomfortable with, but they even hold a horror of this thing called plastic* that denies death; that even when death of use/function finally comes, death is not reflected in a change of shape or similar deterioration". One of the most popular strategies adopted by designers seeking to enliven the surface qualities of plastics for improving the bad image they had in different societies was to pattern it- often copying natural materials such as wood or marble (Dormer, 1990). However, this approach did not last for long. In the 1950s, just the opposite philosophy prevailed with the introduction of *Tupperware*'s new products, which were flexible, light in weight and soft to the touch (Clemenshaw, 1989). A new tactile experience through plastics embodied in Tupper's new set of products was offered to users. With parallel improvements of their technical and sensorial qualities and with breakthrough applications, since then, the value attributed to plastics has drastically increased.

After the establishment of their new status, critiques on their environmental impacts and disposal patterns stimulated severe reactions on the use of plastics (Ashby and Johnson, 2003). These reactions incrementally continue (Albertsson et al., 1987; Rosentrater and Otieno, 2006). Tons of plastics are discarded everyday and they may persist for centuries leading to a familiar scene of bulky wastes on landfills (Weisman, 2007). Rethinking plastic materials and their use are emphasized as keys to sustainable product development (Ashby, 2009; Bovea and Vidal, 2004; Crabbé et al., in press; Ren, 2003; Ribeiro et al., 2008). Deriving from renewable resources, bio-plastics have been considered a possible alternative to plastics derived from fossil fuels. Available literature covers the environmental performance of bio-plastics, their suitability as an alternative to regular ones, developments in their physical structure, their cost and diverse applications (Brehmer et al., 2009; Du et al., 2004; Jayaraman et al., 2011;

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Khoramnejadiana et al., 2011; Kim and Sharma, 2012; Lopez et al., 2011; Mumtaz et al., 2010; Piemonte, 2011). In contrast, a stark gap can be found in literature, articulating how these materials are received by users. Even though the principle of using such materials with improved environmental credentials is rational, it is the users' appreciation of those materials that ultimately determine their commercial success. Recognizing this, a number of bio-plastic developers approached us with the following question: Can we introduce bio-plastics in a new way, so that they will be perceived as natural (coming from nature and returning back to nature) and high-quality by society?

Product designers play an important role in setting new aesthetic values, presenting materials in different contexts and forms, with different properties. Previously mentioned 'Tupper Case' is one of the well-known examples supporting this statement. We suggest that designers - in collaboration with material developers - can construct effective strategies to introduce bio-plastics as 'natural' and 'high-quality' materials. Design research can facilitate this process by providing insights about the user-material-product interrelationships in the attribution of the desired meanings to bio-plastics. Aiming at the creation of these insights, this paper presents when a material is appraised as 'natural' and 'high-quality'. The attribution of these two meanings to materials is explored in an empirical study conducted with 60 participants living in The Netherlands. The results of this study are used for generating two meaning-material patterns as guidelines for designers and bio-plastic material developers.

After a brief introduction to bio-plastics in design, in Section 3 we describe the method used to explore how materials get their meanings. Then we elaborate on the results of the conducted study based on the generated meaning-material patterns. In the last section, the results are discussed in reflection to bio-plastics.

2. Bio-plastics in design

Over the past decade, the demand for solutions to move to a society that has its production based on environmentally responsible materials has rapidly increased (Alvarez-Chavez et al., 2012; Alves et al., 2010; Geiser, 2001; Ren, 2003). In this scenario, high performance plastics are likely to keep being used to meet specialist applications, but use of commodity plastics such as PE, PP and PS - representing the largest volume of plastics use - may be significantly reduced. Being one of the most promising renewable source materials, bio-plastics (e.g. PLA) are considered as one of the highest potential candidates to replace commodity plastics.

Bio-plastics are made from renewable raw materials such as vegetable oil, corn starch etc. or from non-food sources (i.e. cellulosic feed stocks, grass, residual biomass) (Alvarez-Chavez et al., 2012; GDiGregorio, 2009; Mojo, 2007; Swain et al., 2004). Bio-plastics are regarded promising alternative materials not only because their feedstocks are renewable, but also they can be (theoretically) composted and recycled, and their production process can be more energy efficient than petroleum-based ones (Alvarez-Chavez et al., 2012; Ren, 2003). Currently bio-based plastics are mainly used in the packaging industry. However in recent years many attempts have been made at developing high performance bio-plastics that can be used in consumer-electronics, automotive, and other durable consumer goods (GDiGregorio, 2009; Mojo, 2007; Rosentrater and Otieno, 2006; Waltz, 2008).

Lefteri (2006) explains how with the emergence of bio-plastics the image of plastics could change from being an environmental 'criminal' to a material that comes from nature and returns to nature. However, changing the settled image of plastics is not easy or not as smooth as expected. Bio-plastics seek for their own identity (Rognoli et al., 2011) that will help them to be recognized in the market and will make them desirable to be possessed and to be used. Scholars in the domain emphasize that aesthetic values elicited through materials-form-process relationships can have a great influence on the consumption patterns of societies by steering them towards environmentally sensitive materials and products (Papanek, 1995; Vezzoli, 1999; Zafarmand et al., 2003). Following the principles of recent research in materials and design (Karana, 2009; Rognoli, 2010), we suggest that the appraisals of bio-plastics as 'natural' and 'high-quality' materials can be facilitated by modifying their sensorial aspects, associated processing, product aspects and their context of use.

3. When are materials perceived as 'natural' and 'High-quality'?

A meaning of a material is evoked by the interactions between product aspects (such as shape, function) and material properties, with respect to how and in which context the material is used and who the user is. Thus, a meaning of a material can not be reduced to a single property or a single sensory domain (Karana et al., 2010). Therefore, it is not possible to define simple design rules for a certain material-meaning relationship. Nevertheless, there are some patterns that identify how materials obtain their meanings (Karana, 2009; Karana et al., 2010). A material, for instance, may express professionalism when it is smooth and dark (coloured), when it's used in an office environment and when certain technical properties are combined for enhancing its function (e.g. combining strength and lightness). We assume that a designer who can understand these relationships (which we may call 'meaning-evoking patterns') can more deliberately (or systematically) manipulate meaning creation in selecting and applying materials in a design process.

In order to make designers capable of finding these patterns, a method termed Meaning Driven Materials Selection (MDMS) was developed by Karana (2009). The method conveys the idea that many meanings can be attributed to many materials, dependent on different products and contexts. MDMS first offers a method for conducting design research to explore people's material-meaning relationships; then supports designers in converting the results of the conducted research to tangible material properties which facilitate the attribution of the desired meanings to materials. Furthermore, it familiarises designers with the key aspects (such as shape, user, manufacturing processes, etc.) playing an important role in attributing meanings to materials. In MDMS research, a group of people are approached to participate in a study where they are given the following three tasks: (1) select a material that you think is '*X*' (such as high-quality, feminine, modern, etc.), (2) provide a picture of the material you selected, and (3) explain your choice and evaluate the material on the given sensorial scales[1] (Fig. 1).

On an additional page, they are instructed that the *pictures* in task 2 may either be photographs taken by themselves or others, or any type of visual (photo, modelling, etc.) taken from the Internet, magazines, or a similar source. They are asked for a supplementary detailed picture in cases where the selected material is not embodied in an object's whole, but in a part of it. In other words, two pictures are needed if the object is made of more than one material: one for the entire object and one for the part made of the material that expresses the given meaning.

The results are evaluated both qualitatively by analysing the provided images and descriptions from the participants and

[1] After conducting a number of studies in recently done PhD research by Karana (2009), a set of sensorial properties grouped under different sensory modalities was listed, and promoted as the properties that are more commonly used for attributing meanings to materials (Karana et al., 2009).