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OLFACTORY PERCEPTION: STUDY OF ENCAPSULATION OF ORANGE OIL FOR APPLICATION IN PRODUCT DESIGN

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ABSTRACT

The relation of product to user directly involves perceptual and sensory aspects; touch, sight, taste, smell and hearing. Among them, there is an important area, but little explored: olfactory perception of certain products. In this sense, the present work aims to contribute to this area of research through the study of encapsulation techniques of orange essential oil and its implementation in the olfactory perception focusing on product design and materials science. New materials and processes are important when we want to stimulate emotions and new research on technological innovation (Rocha et al., 2010; Hekkert and Schifferstein, 2008). The method used was the interfacial polymerization and ceramic microcapsules were formed with tetraethyl orthosilicate synthesized by the sol-gel method (Ghosh, 2006). The microcapsules were produced in the laboratory and characterized by Scanning Electron Microscope (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). An important factor in the development of the encapsulation consists in the control release of the scent during the life of the product and the application on different medium such as fabric, wood, among others. As Nelson (2002) and Monllor et al. (2007) emphasize only the microencapsulation process is able to maintain a fragrance for a longer on a fabric with aromatic microcapsules configured by the presence of essential oils as the active material. The shell provides greater stability as oil dispersion in the medium. As a result, it was possible to produce shells with orange oil encapsulated.

Keywords: Microcapsules, essential oils, olfactory perception, Emotion Design.

1 INTRODUCTION

Emotion has a strong and necessary burden in life, affecting how we feel, act and think. These aspects are very important and deserve a special attention concerning a product design. There is a interaction force between products and individuals. In this sense, the study of perception is essential to achieve the necessary goals of user-product interface, which are responsible for triggering emotional factors that tend to be valued by designers: the market is saturated and competition is increasing, presenting a necessity to invest in projects with differential and greater usability. The decision is directly linked to emotions and to the cognitive system, and it is fundamental to the relationship between the individuals and the world around them (DAMÁSIO, 1996; KHALID, 2006; ASHBY and JOHNSON, 2011).

Perception is the interpretation result of what is observed. The same product can be perceived in different ways by the users, whose reaction is triggered by

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experiences, livings and mental images constructed over time. Both perception and observation contribute to the design creativity, reflecting in the industrial design and in the product personality. There are aesthetic attributes related directly to the senses, which refer to a time, place, culture or event. Perceived attributes decipher the reaction that people have towards a material or a product, depending on the context and the user experiences. For example, fun and amusement, or emotional attributes, describe the feeling that a product or material reflects in the user: it can be happiness, sadness, threat (ASHBY and JOHNSON, 2011).

In the current context, we have more demanding users, who require increasingly good functionality and usability of products and minimum requirements for their purchase. According to Jordan (2000), the relationship man-product is emotional, with an important role in the development of projects with all features functional and emotional differences. It is known that the usability is also related to emotion. A product that has a unique and emotionally adequate usability is understood as distinct and easier to use (NORMAN, 2004).

According to Damasio and Mont'Alvão (2008) "the design centered on the object and its objective aspects began to be replaced by a human-centered design and in his way of observe, interpret and live in the environment." Krippendorff (2001), corroborates saying that the designers started to realize that their products were not just "things", but social practices, and that the people to whom they were projected were not only "rational users". According to this author, "we do not react to the physical qualities of things, but to what they mean to us" (KRIPPENDORFF, 2001).

Thus, it can be stated that it is of extreme importance in product project to take into account the materials selection that can sharpen the user’s perception. As Johnson (2001) points out, it is essential in design to find solutions that are meaningful to people, that provide them new experiences. Lobach (2009) also emphasizes that the more levels of observation a particular product offer to the user perception, not only greater will be the time that this information will remain in their memory, but also the attention retention will be immediate. We know that we interact with the materials of the contact interface, and there are several attributes such as technical, aesthetic, sensory that will interfere with the user–product interface.

Some evoke the emotional dimension, others insist on their physiological and behavioral aspects: "the tendency to act." Neuroscience has classified the emotions as simple and secondary. They are called simple or primary when they are accompanied by facial expressions or universal gestures, regardless of education and culture (BUCKLE, 2000).

A study from the Rockefeller University (New York) found, in 1999, that the human being is able to remember 35% of odors, 5% of what he has seen, 2% of what he has read or has eaten and 1% of what he has touched. It is extremely important to study the sensorial sense repercussion as long as we do not focus only in the visual system, but in the other sensorial organs also (Santaella 2004; apud Dias, 2009).

According to Santaella (2004), more than any other sensory modality, the sense of smell triggers an emotion, positive or negative in the user- product interface. Some odors reproduce the induction of emotional states by modifying the odor perception. Some brain substrates are, in fact, common to the emotional and olfactory processing.

Within this context, among the senses that allow the user-product interaction, the sense of smell is one of the most important to focus. It is critical to understand this system since the understanding of the perception of aroma is essential to understand the therapeutic action of essential oils. Wolffenbuttel (2011) and Soudrya *et al.* (2011) stresses that the olfactory bulb is the first mechanism of the olfactory system, which has about 8000 glomeruli that receive axons from the primary olfactory neurons. More than any other sensory modality, the sense of smell shares with the emotions the ability to assign a positive (appetitive) or negative (aversive) valence to our environment. A smell can be defined as a particular feeling produced by the action of certain chemicals in the olfactory system (SOUDRYA *et al*. 2011).

This work aims to address the exploratory applicability of microcapsules containing orange volatile oil (olfactory perception) and its application in different supports, focusing on design. Innovation is the great principle to be achieved. The structural morphology of the material is directly related to the mechanical anchoring of the microcapsules, which was taken into consideration in their production.

2 LITERATURE BACKGROUND

Essential oils are composed of different chemical constituents that can even exceed 300 components. This feature provides to the pure essential oil a very high value. Its applications are numerous, for example, in perfumery, cosmetics, food, health as a therapeutic, environmental and fashion potential (use of oil in fiber and materials), which is a new area being explored. Essential oils have been used since earlier then the ancient Egypt times, passing by several ages until the early twentieth century with the treaties of Aromatherapy. There are nowadays new nomenclature as aromacology and aromatology. New researches triggered the evidence of essential oils use with different approaches, for example, as antidepressant, insect repellent, antibacterial, stimulant, etc. The assimilation of essential oils in the body can occur by absorption via inhalation and dermal (WOLFFENBUTTEL, 2011).

According to Alexander (2001), it has become evident in recent years the importance of essential oils through the olfactory system, while the application in the skin have shown a beneficial effect on the immune system. Studies show that essential oils modulate immunity improving mood, mental activity and biological activity of the organism in body healing processes. There are three ways in which the active ingredients of essential oils modulate the immune system:

a) First, after been ingested and detected by the olfactory system, the oils activate the brain chemical system regarding the affective part, the humor, which directly affect the immunity;

b) Second, the essential oils can be used as agents that positively affect the immune response;

c) Third, but not least, the oil can be applied in the dermis for cellular and immunological direct results.

The author also emphasizes that in order to understand how essential oils directly influence the immune system through the olfactory system, it is necessary to know the neural relations of three important systems such as the

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endocrine, nervous and immune system, together with the olfactory system process (Alexander, 2001).

The combination between how smells affect the mind and how the mind affects the immunological function are basic for immune modulation. The mind is not the only human command governing the memory, but the cells of the three systems (endocrine, nervous and immune) are susceptible to "learn" and "condition" and can be adjusted to change or respond to essential oils with the olfactory order to prevent or mitigate adverse immune reactions. The essential oils consist on molecules able to exert pharmacological effects and act as chemo-preventive agents, anti-inflammatory or chemotherapeutic in more severe disease (ALEXANDER, 2001).

Brazil is increasing the development of the cosmetics industry mainly within the economy. Essential oils are popular in the pharmaceutical, therapeutic and cosmetic areas, according to Brito *et al.* (2014).

"*Every year the world production of essential oils of thirty aromatic species is estimated between 110,000 and 120,000 tons and its use is not restricted to aromatherapy*", these oils are also used in the cosmetic, food, cleaning products and beverage industries (GARLET *et al*., 2007 *apud* BRITO *et al.,* 2014). There are many results in current research studies with the millennial use of aromatherapy, stressing it as a wellness practice and complementary therapy.

The authors also emphasize that many industrialized countries recognize and employ aromatherapy, recognizing it as a therapeutic effective method. England and France are considered advanced countries in this area presenting serious and quality studies. Brazil is the third largest exporter of essential oils in the world, behind only the United States and France. Orange, lemon and eucalyptus oils are the most exported (BRITO *et al*., 2014).

Several studies show that the smell of environments affect the perceptions and moods, cognition and performance, automatically influencing health (ROBERTS & WILLIAMS, 1992 *apud* ALEXANDER, 2001). Also, other studies show that the olfactory essential oils present pharmacodynamic effects in the chemical area of the brain, have potential immunological effect (VALE *et al*., 1999) and that the olfactory stimuli may cause alterations and changes in blood pressure and skin temperature parameters as well as reducing anxiety (GNATTA *et al*., 2014). Briefly we can then see that the behavior and body chemistry area are affected by olfactory perception (psychological response) and smell neurotransmitters. It has been also reported that people who do not feel smells are also affected by scents, because the stimulation of olfactory receptors occurs, and the brain receives this stimulus (NASEL *et al*., 1994).

Pleasant effects of aromatherapy are extremely important factors, which enhanced the dynamics of health. Experiments done by measuring the effects of scents in the perception of health suggest that this olfactory perception has a power to affect health (KNASHO, 1993 apud ALEXANDER, 2001).

Microencapsulating these oils become an option for the application of different materials and products. In order to understand the choice of microcapsules it is important to comprehend the process as Ghosh (2006) defines many objects we encounter in our daily lives, including the house in which we live and the materials we use (for example, toothbrushes, pots and pans, refrigerators, televisions, computers, cars, furniture). According to him, they are all under the "umbrella" of coating materials. Clearly, the importance of coating increased

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enormously during the modern era of technology. The coating is defined as a material (usually liquid) that is applied to a surface and appears as a continuous or discontinuous film after drying. However, the application process and the resulting dry film are also considered coating. The liquid coating drying is performed mainly by evaporation (cross-linking) by oxidative, thermal or other methods of ultraviolet and visible light. Microencapsulation allows to isolate a product that is on the external media (HIRECH, 2003). This whole process generates new value-added products (MONDAL, 2008).

It is well known that the pharmaceutical industry uses this technology and have been using microencapsulation for preparing capsules containing active drugs, but over time, a variety of new technologies have emerged and are being developed in various fields of research. During the past 10 years, this approach has been widely exploited for agriculture, food, cosmetics and textiles. Microencapsulation provides the possibility to combine the properties of different types of materials (organic and inorganic) in a process which is difficult to achieve using other techniques. Important advantages of this technology are the controlled delivery system for drugs (GHOSH, 2006; SIEPMANN, 2006).

Microencapsulation is defined as a process which encompasses micron sized particles of solids, liquids or gases in an inert shell, which make them isolated and protected from the external environment. The inertia is related to the lack of reactivity of the shell with the core material. This technology is used primarily for the purpose of protection, controlled release and compatibility of the core materials. The microcapsules core materials can range from essential oils and enzymes to dyes, salts and water. According to You *et al*. (2010), there are many benefits and reasons to use microencapsulation as a controlled release: protection of unstable materials in contact with the media, ability to work with liquids as with solid, among others ACHARYA *et al.,* 2010; REN *et al., 2010*).

According Hammad *et al*. (2011) the encapsulation techniques existent consist in physical and chemical methods. Physical methods: spray drying, spray chiling, rotary disk atomization, fluid bed coating, stationary nozzle coextrusion, multiorifice-centrifugal process, submerged nozzle coextrusion, pan coating, air-suspension coating, and centrifugal extrusion. Chemical methods: coacervation, phase separation, solvent evaporation, solvent extraction, interfacial polymerization, simple and complex coacervation, *in-situ* polymerization, liposome technology, nanoencapsulation and matrix polymerization.

There are many applications, such as forming adhesives, chemicals, food additives, agrochemicals, flavors and essences, pesticides and herbicides, cosmetics, pharmaceuticals, nutraceuticals, among others.

Hammad *et al.* (2011)[1] points out that the definition of the shell or the type of material forming the shell depends on the particular definition of the material to be encapsulated in the core, which may be liquid or solid. The composition can be variable and may include dispersive or dissolved materials. The shell solid coat may be the result of a stabilized mixture of active constituents, diluents and accelerators. The great advantage is the ability to vary the composition of the core material and provide flexibility in the use of this feature, allowing effective design and development of the desired properties of the microcapsule.

The authors emphasize that although there are significant advances in microencapsulation area, there are still many challenges that need to be corrected in the proper selection of core, coating materials and process techniques.

According to Hammad *et al*., (2011), there are some reasons for encapsulation. In some cases, the core must be insulated from its surroundings, for example in the isolation of vitamins, decrease in the effects of oxygen deterioration, evaporation reduction of a volatile core and improvement of the handling properties of a viscous material.

There are several reasons why the substances can be encapsulated. Hammad *et al*., (2011), explain:

a) Protect reactive substances from the environment;

b) Convert liquid active components in a dry solid system;

c) Separate incompatible components for functional reasons;

d) Mask undesirable properties of the active components;

e) Protect the immediate environment frm the active components of the microcapsules;

f) Control the release of the active components in relation to the delayed release (timer) or long-acting release (sustained).

The resulting product from the microencapsulation process is called a "microcapsule", which are micron sized (<1 mm) and have a spherical or irregular shape. The microcapsules can be divided into two parts: the core and the shell. The core (inner part) contains the active ingredient, while the shell (the outside) protects the core form the external atmosphere, permanently or temporarily. Core materials in the microcapsules can be in the form of a solid, liquid or gas. The core materials are used most often in the form of a solution, dispersion or emulsion. Compatibility of the core material with the coating is an important criterion for improving the microencapsulation efficiency. The core size plays an important role for the diffusion, permeation and controlled release applications. Depending on the function, a variety of core materials may be encapsulated, including pigments, dyes, catalysts, curing agents, plasticizers and fragrances (GHOSH, 2006).

Microcapsules and microspheres can be provided to clients by the food industry, pharmaceutical and cosmetic industries, as personal care products, agriculture, veterinary medicine, industrial chemicals, biotechnology, biomedical, and sensor technology (UMER *et al*., 2011).

The variety of natural and synthetic polymers provides a wider scope in the choice of coating material, which can be permeable, semi permeable or impermeable. Permeable shells are used for controlled release applications, while semi permeable capsules are generally impermeable to core material, but permeable to liquids of low molecular weight. Thus, these capsules can be used to absorb substances from the medium and release them again when brought out to it.

There are two basic structures that can be produced in the microencapsulation process: the "reservoir" and the "matrix" system types. In the first, a mononuclear particle is surrounded by a thin wall (microcapsule), and in the second, the encapsulated material is distributed systematically at the core of the capsule (microsphere) (VERSIC, 1998). The interfacial polymerization occurs through the dissolution of two monomers that complement each other and generate two immiscible solvents. The aqueous phase, in contact with the organic phase, forms a thin polymer layer that will be removed and handled subsequently. Several positive aspects are presented for this method as the possibility of proceeding at room temperature, without the need for high temperatures, fast reaction time and no need to have a precise stoichiometric equivalence (KAGE *et al.*, 2002). The reagents or monomers are responsible for the interfacial polymerization to form the microcapsule shell, being present in the two phases.

Obtaining and applying microcapsules became a field related to the research in technological innovation and to the necessity to create a parallel with new materials and processes in the market (ROCHA *et al*., 2010). The application of emerging technologies arising from current research in the field of materials and processes improved the universe of products, addressing issues of comfort, convenience, necessity and desire. In the user-product perceptual interface there is a demand that encompasses the needs and desires in the relationship with products, affecting in the choice of materials and design (HEKKERT and SCHIFFERSTEIN, 2008). This perception includes the five senses (sight, smell, hearing, touch and taste). Technically, it is possible to modify the material by applying microcapsules, which presents itself as an alternative to change the material properties and consequently the user perception (MONLLOR *et al.,* 2007.

3 **MATERIALS AND METHODS**

We choose to work with the orange essential oil for its therapeutic properties, since according to the aromatherapy area this oil is of great use to combat stress, nervousness and depression through its volatility and the active components uptake by the olfactory system. The offer and the cost are factors that influenced the choice of the orange essential oil, since it is a widely used product in Brazil. In addition, the orange tree is one of the most planted and studied tree worldwide.

To continue the controlled release of the aroma, we focused on designing microcapsules in order to impregnate it in different supports. In this study, polymeric microcapsules of melamine were developed by interfacial polymerisation *in situ* method. This method consists in the dissolution of two monomers that complement each other, generating two immiscible solvents The aqueous phase, in contact with the organic phase, forms a thin polymer layer that will be removed and handled subsequently. The reagents or monomers are responsible for the interfacial polymerization to form the microcapsule shell, being present in the two phases.

For the development of experimental procedures preliminary tests previously and after the application of the microcapsules produced. The volatile oil was analyzed by Fourier Transform Infrared Spectroscopy (FTIR) to assess its chemical constituents.

For the production of microcapsules the following equipment were used: electronic scale, automatic pipette, one jacketed beaker 500 mL, 50 mL beaker, magnetic stirrer and mechanical shaker with agitation of 200 and 500 rpm, ceramic filter, ultrasound, desiccators and centrifuge. As production materials: deionized water, formaldehyde, melamine, essential oil, acetic acid solution 50%, triethanolamine solution 60% and surfactant (cetyltrimethylammonium bromide, Tween 20®, Tween 80® or sodium lauryl sulfate).

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In the first moment, to obtain polymeric microcapsules it was used as reagents: deionized water (200 mL), melamine (2.5 g), formaldehyde (6 mL) at a temperature of 70 °C. Emulsion pH was adjusted to 4.5 with acetic acid solution (50%). Pre-polymer pH was adjusted to 8.5 with triethanolamine 60%. The essential oil, initially, was used at a 10 mL volume, but many lump microcapsules were formed, and also, it did not show satisfactory dimensional and morphological appearance. Thus, we kept the same items listed with variation of the volatile oil to 8mL.

To prepare the emulsion, 200 mL of deionized water were placed into a 600 mL jacketed beaker. The surfactant was added and mixed until completely solubilization. Immediately after, it was added 8 mL of orange essential oil and the solution was taken to the ultrasound for 10 minutes. At this point, the pH was adjusted to 4.5 using the acetic acid solution.

The pre-polymer was prepared on a 50 ml jacketed beaker, with 7 mL of deionized water and 6 mL of formaldehyde. Under magnetic stirring at 70 °C it was immediately added 2.5 g of melanin and waited until the solution became clear again. Then the pH was adjusted to 8.5 using a triethanolamine solution. The stirring was regulated to 500 rpm while the pre-polymer was added by drops into the emulsion in the jacketed beaker at 70 °C. This solution pH was adjusted to 9.0 with triethanolamine. After the solution decanted it was centrifuged at a 10,000 rpm for 30 min. The paste formed was removed and transferred to a desiccator to dry out.

The microcapsules were analyzed and characterized by Fourier transform infrared spectroscopy (FTIR) and the scanning electron microscope (SEM) to analyze their format and size.

4 RESULT AND DISCUSSIONS

The size and morphology found were the best results for the microcapsules tested with different surfactants such as Tween 80®, Tween 20®, and SLS and CTAB (all tested separately). The use of different types of surfactants used in conjunction with agitation resulted in different sizes and characteristics. Dimensions between as 1.73 micron to 3.87 micron were found, however we choose the microcapsule prepared with surfactant Tween 20®.

As emphasize Kheradmandnia *et al.* (2010), the particle size decrease with increasing surfactant content. They found out that the surface tension reduction with the increase surfactant concentration facilitates the particles partition during homogenization and contributes to the particle size decrease.

In Figure 1 we can see the orange essential oil microcapsules through a scanning electron microscope (SEM), demonstrating dimensions of 2.23 (μm), 2.33 (μm). It appears that the microcapsules obtained possess morphological and dimensional equilibrium allowing impregnation in different materials.

There are several supports that can be impregnated with volatile oil microcapsules prioritizing olfactory perception and enabling to add value to the products applied. These properties are enhanced with the touch, since the microcapsules shell opens providing the essential oil volatile components release. There are several products that can benefit from these impregnations, from toys to furniture, lamps and packaging. Through the use of this technology it is possible to incorporate olfactory perception in new design projects.

It is known that impregnation tests are needed to verify the effectiveness of microcapsules focusing in the oil controlled release from the support.

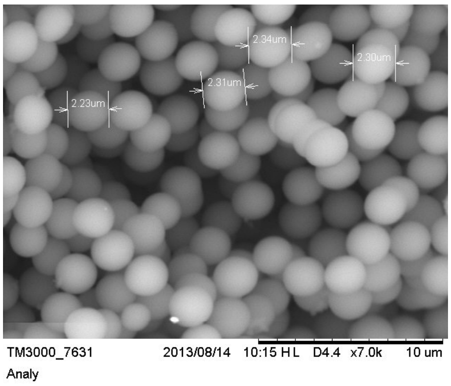

Figure 1 – Scanning electronic microscopy (SEM) applied in the microcapsules.

5 **CONCLUSIONS**

Once obtained the orange essential oil microcapsules, they can be applied in various supports, including textiles, foams, paints, paper, leather, allowing the designer to insert variables of olfactory perception in their designs projects focusing on user-product interface.

It is known that the essential oils active components release is helpful regarding the well-being of the user. Therefore, extensive studies will be performed for the essential oil release in the impregnation of different supports.

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