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Rodrigo Mero Sarmento da Silva
Professor
Federal Institute of Education, Science and Technology of Alagoas
Brazil

Amanda Lys Matos dos Santos Melo
Student/Researcher
Federal Institute of Education, Science and Technology of Alagoas
Brazil

Filipe da Silva Duarte
Student/Researcher
Federal Institute of Education, Science and Technology of Alagoas
Brazil

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Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
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Prototypes of an Air Incorporating Bioadditive Derived from Castor Oil

Rodrigo MeroSarmento da Silva
Amanda Lys Matos dos Santos Melo
Filipe da Silva Duarte

Abstract

Economical, efficient and sustainable additives that optimize the use of natural resources and minimize the adverse impacts of these activities on the environment are in a global shortage for construction. The air incorporator additive, developed industrially, used for the manufacture of cellular concrete is being widely utilized due to the growth of works that use the constructive system of walls and structure with this type of concrete, which has a specific, substantially reduced weight, thus creating a significant saving in cost. The current substances used for producing this additive are linear alkylbenzene and miscellaneous materials. Due to the high toxicity of the components in these substances, the current additives might be harmful to the environment. In the face of this problem, this project developed an air incorporator bioadditive oil prototype based on castor plant (Ricinuscommunis l.), collected in the city of Arapiraca-AL, northeastern Brazil. This was possible after the verification of some of their physical and chemical features when compared with international standards. This research has the purposeto contribute to the improvement of the Brazilian construction industry in an economic and efficient manner without harming the environment.

Keywords: Additive, Castor, Concrete, Sustainability.

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Introduction

Widely used in the construction industry, additives are chemicals that when added to cement, mortar or concrete modify one or more properties of the blend. Due to the expansion of use, as a result of theirability to improve various mixtures, additivescan beconsidered as the fourth component of concrete, besides water, cement and aggregates.

An additive that is being increasingly used is the additive type IA (air incorporators). It is used in the making of so-called "cellular concrete", widely used in Brazil due to the growth of the works that use the constructive system of walls and structure with this type of concrete. This additive aims to produce a microscopic bubble system that is stable and uniform, producing concretes with reduced specific gravity, and with better thermal, acoustic and substantial material savings.

The present air incorporator additives consist mainly of linear alkylbenzenesulfonates, such as alkyl-aryl-sulfonated. It is an anionic surfactant, which is considered toxic due to its surfactant activity. Some of the main environmental impacts of this substance are the decreases in concentration of elements necessary to aquatic life. This includes, for example, dissolved oxygen, due to the reduction of water/air surface tension; light permeability, due to the superficial layer of particles present in suspension; increases in the concentration of xenobiotics and mainly the formation of foam and consequent inhibition of autodepuration of the watercourses and dissemination of impurities.

Other substances used for this type of additive are miscellaneous materials, such as petroleum residues, alkalis acids salts and salts of alkalis lignosulfonates. The residues of such substances exhibit wide variations in composition and, because of their high toxicity, they cannot be disposed in nature.

The main components used for the manufacture of this type of additive are known; however, the chemical methods and processes necessary for their manufacture are not revealed by the industrial sector, and there is no bibliographic reference on the subject. Nevertheless, we can understand that the industrial sector producing this additive is deficient in its environmental concern.

According to the energy company of Minas Gerais - CEMIG (1986, quoted by Paes et al., 2015, p.135), the castor (Ricinuscommunis L.) has a low production cost; high climatic adaptability; low requirement of soils, and high capacity of production of oils by area. In light of these features, it was the vegetable selected for study and possible development of abioadditive.

The castor is an oleaginous plant, belonging to the family Euforbiaceae, thatoriginated in Africa and arrived in Brazil in the colonial period (Ventura, 1990). Brazil has already played a prominent role in the world production of castor bean (Santos et al., 2007). According to FAO (2008), in 2008, the world producers were India (1,123,000 ton), China (220,000 ton) and Brazil (120,449 ton).

Castor seed is composed of 75% almond and 25% cask, on average. The amount of oil extracted from the seed is between 40-60% by weight. Among the main components, the most important is thericinoleic (12-hydroxy-9-octadecenoic acid), which represents approximately 90% of the total oil composition (Koutroubaset al., 1999). This acid is an unsaturatedhydroxy acid (hydroxylated carboxylic acid) that has a high molar mass (298) and low melting point (5 °C). The total amount of unsaturated fatty acids (including ricinoleic acid) accounts for about 97% by mass of this vegetable oil. The concentration of saturated fatty acids in the seeds is only 2.3-3.6% (Moreno and Cordoba, 1997).

The purpose of this study was to develop a bioadditive prototype incorporating air based on the oil of the castor bean plant collected in the city of Arapiraca-AL, northeast Brazil. Due to the absence of references on manufacturing methods for this type of additive, a new method was developed based on chemical and physical characteristics of the vegetable oil. A concentrated solution of neutral natural detergent based on the oil extracted from the plant was synthetized through saponification reaction. Subsequently, some experimental measurements on the chemical reactions were performed until a prototype was obtained.

Literature Review

The Castor Oil

According to WEISS (1983), the castor bean belongs to the Euforbiácea family, species Ricinuscommunis L and class Dicotiledoneae, Geraniales series. According to Coelho (1979), it is a xerophilous plant of Afro-Asian origin, which does not tolerate excess water butis quite tolerant to dry climates; the plant also demands a lot of heat and luminosity to grow. In the industrial culture, castor bean is exploited due to the oil contained in its seeds; the oil extracted from this vegetable is of excellent quality.

Beaver oil differs from other vegetable oils because of the large amount of hydroxides. According to SavyFilho et al. (1999), in the composition of this oil the presence of the triglyceride ricinoleic acid is of 90%, and in addition, it presents/displays three reactive groups that allow a large number of chemical reactions due to the presence of the carboxyl groups on carbon 1, hydroxyl on carbon 12 and a double bond on carbon 9.Thisprovides useful features for the production of various industrial products. Although it is unfit for human consumption, its importance is concentrated in the several industrial applications as raw material for the manufacture of several products (Chierice and Claro Neto, 2001).

Due to the presence of the hydroxyl group in the composition of the castor oil, it is possible to obtain high viscosity and stability, which, by forming intermolecular hydrogen bridges allows wide temperature ranges (Muller, 1978). Besides having stability in the oxidation, it becomes solid in low temperatures. The hydroxyl association gives it its own characteristic of its alcohol solubility (Weiss, 1983; Mohsenin, 1986). According to Beltrão(2003), it is aunique glyceride made by nature, soluble in alcohol, and considered one of the most dense and most viscous of all animal and vegetable oils.

The oil yield of castor bean seeds varies from 35 to 55%, the commercial standard is 45% (Vieira et al., 1998). According to Gaspar and Silva (1956), the classification of the oil in the commercial industry is as follows: number 1 as industrial oil, with a maximum of 1% acidity, bright and clean; Number 3 as commercial, whose impurity and acidity must not exceed 1 and 3% respectively. As for the extraction procedure, the oil can be acquired through several methods, by pressing, cold or hot, or by solvent extraction, among other mechanisms (Macedo, 2004).

Production and Consumption of Castor Oil in Brazil

The world's largest producers of castor oil are India and China, but Brazil remains one of the largest exporters (SavyFilho et al., 1999). Domestic oil production in Brazil experienced a decline in the 1980s and 1990s, showing the decline of the castor bean crop in this period, which resulted in a reduction of gross income of the rural producers. Since the launch of government programs that seek to promote and improve biodiesel production in the country, castor oil production has shown signs of improvement (CONAB, 2004).

The production of castor bean in Brazil is centered in the Northeast region, especially in the semiarid region. The production is composed primarily ofsmall family farmers, who make associations with food crops and do not use improved cultivars. The affiliation of the castor bean crop with family agriculture is due to its resilience during droughts and good adaptation in the defined characteristic conditions of the Brazilian semiarid land. This type of crop requires only moderate mechanization in its treatments and generates good crops, even if it is cultivated in a way associated with beans and corn,whichis ideal for family farming (Barros and Ramos, 2012).

Air Incorporator Additive

Additives are products added in small proportion tothe mixture of mortars or concretes, with the aim of modifying favorably the characteristics of this conglomerate, either in the fresh or hardened state (Bueno, 2000).

The air-entraining additive can be considered one of the great advances in concrete technology. Developed in the 1930s, it introduces microscopic air bubbles into concrete. These bubbles significantly improve the durability of the concretes subjected to freezing and thawing stages, providing greater workability in the fresh state (Kosmatkaet al., 2003).

According to the 45th edition of the technical manual for concrete additives of VedacitImpermeabilizantes (2009), this type of additive increases the workability of concretes, especially in traces with low cement consumption and deficiencies of fine granulometry, improving the properties of the fresh concrete, making it more cohesive, reducing segregation and increasing impermeability. It is generally used in combination with a water reducer/retarder for maximum mechanical resistance. As for the fields of application, it can be used to make concrete for conventional use, concrete in contact with seawater, poor concrete in fines or mortars with poor traces in cement. Its approximate consumption is 0.04 to 0.12% of the mass of cement, according to the desired air content.

The main use of this additive in Brazil is for the creationof cellular concrete, due to the growth of the works that use the constructive system of walls and structures with this type of concrete. The use of this type of additive in the mix aims to produce a microscopic bubble system that is stable and uniform, producing concretes with both reduced specific gravity and better thermal, acoustic and substantial concrete economy (Antonio and Recena, 2014). According to the book "Retraction of Concrete" (2014) by Fernando Antonio andRecena, in cold-weather countries, this type of additive is widely used to reduce or eliminate damages caused by ice-melt cycles, as in the United States. The air bubbles added to the concrete provide free space for freezing water to expand, thus reducing internal stresses, and thereby avoiding cracks in the concrete.

Air Incorporator Agents

According to Rixom and Mailvaganam (1999), the discovery of air incorporators occurred randomly. They analyzed the fact that concrete made with cement that used animal fat bubbles as the leader of grinding presented greater durability than concrete made with cement that did not use this leader. The author catalogued some of the tensoactives used in the industry for the formation of air-entraining agents: neutralized wood resins, salts of fatty acids, alkylarylsulfonates, alkyl sulfates and phenols ethoxylates.

Air-entraining agents and water-reducing agents may be pointed to as surfactants. These compounds present in their molecular structure associations with antagonistic features. Thus, in its molecules, there is a polar grouping that has affinity with water, called hydrophilic, and another that has no affinity, called hydrophobic. The inequality between incorporating air and diluting the system is presented according to the molecule orientation (Mehta and Monteiro, 2006). The air-entraining additives are formed by a hydroxyl chain with a finite end in a hydrophilic polar group (Edmeades and Hewlett, 1998).

Thus, the formation of microscopic air bubbles occurs when the surfactants, which constitute the additive, aim their hydrophilic end to the water, thus reducing surface tension and improving the formation of bubbles. This procedure also prevents the bubbles from agglutinating, as this bonding occurs through the hydrophilic film formed around each bubble. The hydrophilic surface isattracted to the fully aggregated cement grainsand aggregates forming an aggregate-air-cement-air-aggregate bridge (Edmeades and Hewlett, 1998).

Concretes with Incorporated Air

Concrete is composed of a mixture of aggregates, Portland cement and water. The agglomerate of the cement to water results in a mass that contours the particles of the aggregates, providing a material that is able to mold to diverse forms. The mechanical efficiency of the formed mixture is acquired over the days through the hydration reactions of the cement, resulting in a compound in the hardened state with a high structural performance (Helene and Andrade, 2007).

However, in order for the concrete to reach the desired characteristics, sometimes the use of additives in the mixture isnecessary. The use of concrete incorporating additives is highly desired, especially in cold climate countries where the presence of voids in the hardened product improves the durability of the concrete elements (Neville, 1982).

The air-entrained concrete features bubbles in its finely spaced air structure. In addition to the other pores present in concrete, the presence of bubbles brings important benefits to the concrete in its fresh and hardened state (Kosmatkaet al., 2003).

Effects of Air Incorporation into Concrete

The incorporation of air in the concrete is useful for a number of reasons, the main ones being: anincrease of resistance to freezing-melting cycles and anincrease of the workability of the mass. These benefits are due to the air bubbles incorporated during the mixing process (Dolch, 1996). The bubbles are isolated from one another by a small strip of paste. However, this presence of air bubbles is followed by a significant decrease in the compressive strength of the concrete once the resistance is a direct function of the porosity of the materials.

Effect of Air Incorporation on the Workability of Concrete

Workability indicates the ease of concrete when being transported, packed, cast, and finalized. In poorer concretes, for the same ratio of water to cement, the incorporation of air results in a greater workability when compared to the same mixture without the use of the incorporated air. However, the effect of the incorporation of air on the workability is smaller in richer concretes (Caldarone, 2009).

When applied to the concrete, the air bubbles remain spherical due to surface tension, resulting in an improved workability. Hence, the bubbles act as a small aggregate with low surface friction and high elasticity. The concrete mass will behave as if there is an excess of small aggregate. Therefore, the loss of mechanical strength due to the voids is compensated in part by the decrease in the sand content and consequent reduction in the water content (Kosmatka et al., 2003).

Methodology

Seeding and Drying of Seeds

The clusters of the castor plant, where the seeds are, do not all develop at the same time in the plant, since the flowering of the castor bean is of the botanical sympodial type. This means the appearance of the inflorescence takes place sequentially in about 20 to35 days between the primary emission, secondary and tertiary inflorescences, leading to split harvesting, for the dehiscent varieties, as the racemes mature, when 2/3 of the fruits are dry (SavyFilho, 2005).

According to RibeiroFilho (1966), the best time to harvest the castor bean is when about 70% of the races are dry; that is, when almost all the bunches of the plant that will be collected are dry.If all are dry, however, it is a sign that the plant in question has already matured for some time and the process of aging has begun, followed by the loss of physiological properties, which is not desirable for the majority of uses of this oleoginous seed.

The castor (Ricinuscommunis L) was collected on the AL-101 highway, between the municipalities of Arapiraca - AL and Craíbas - AL. The fruits were left in the sun to dry and hatch, and then the seeds were stored in plastic bags until the time of their use. Storage must be in a dry and ventilated place. Figure 1 shows the dry, ready-to-use seeds.

Figure 1.*Seeds of Castor*

Determination of Seed Moisture Content

For Filho et al. (1987), the determination of moisture aims to obtain the water content present in the seeds to maintain the physiological quality of the seeds for the purposes of storage and mainly commercialization (Souza et al., 2005). Periodic determinations of the humidity degree, between harvesting and the use in the plantations, allow the identification of problems that may occur throughout the different stages of processing and the adoption of adequate measures for their solution.

The moisture represents one of the most important control parameters for oils, fats and oilseeds, since the stability of these foods decreases with increasing moisture content (Kaijseret al., 2000). Among the methods used, the most common was gravimetry, which is based on the determination of weight loss of the material submitted to heating (AOCS, 2004).

The method for determining the moisture chosen was the method described in "Determination of the water content in castor bean (Ricinuscommunis L.) by microwave and oven methods" (Souza et al., 2005). The method consists of analyzing the weight in grams of water lost through heating in a microwave oven for 7 minutes, thereby obtaining results equivalent to those obtained by the oven method. The time factor is essential in the use of the microwave oven, avoiding the destruction of the samples by prolonged exposure to radiation (Casada et al., 1983). The amount of water in the seeds directly influences many characteristics of their physiology, therefore laboratory determination of seed moisture index is very important.

The assay was performed in foursamples of 2 grams weighed in a scale of 0.0001 precision, in order to compare results and to draw a mean between the values.

Extraction of Castor Oil

The castor bean plant (RicinusCommunis) produces oil-rich seeds. Commercially, there are three methods that are the most commonly used for extraction of vegetable oils: batch hydraulic press, continuous mechanical press and solvent extraction. In this work, we used solvent extraction using ethanol as the solvent for this process. Solvent extraction involvesbringingthe solvent extractor together with the previously crushed seeds in the raw or toasted state. In this study, the crude seeds were used. In this extraction method, a liquid solvent is used to dissolve a solid or liquid substance from a solid mixture containing less soluble substances. In this process, the separation of the phases occurs, and then it is possible to separate the crude oil from the other substances of the seed through simple procedures of chemical separation of mixtures.

The simple filtration process consists of using a filtering paper folded inside a funnel. The simple filtration process differs from vacuum filtration in the matter of intensity. A vacuum filtration process is performed with the use of a pump that lowers the pressure inside the container, resulting in the suction of the mixture being filtrated, thereby increasing the rate of filtration.

To extract the oil, 40g of dried seeds were manually grinded in a mortar and homogenized with 95% ethyl alcohol. The process of separating the oil and ethanol from the mixture was done by vacuum filtration on a buchner funnel. The paste held in the filter was subjected to a simple filtration for 24 hours in order to obtain a more precise yield of the oil. Finally, to remove the alcohol from the oil, the mixture was heated to 80 °C to allow the evaporation of the alcohol. For the calculation of the oil yield, a ratio was obtained between the mass of the dried seeds used and the mass of the oil obtained. Figures 2 and 3 represent the filtering methods used.

Figure 2. *Vacuum Filtration*

Figure 3. *Simple Filtration*

Determination of the Acid Value of Castor Oil

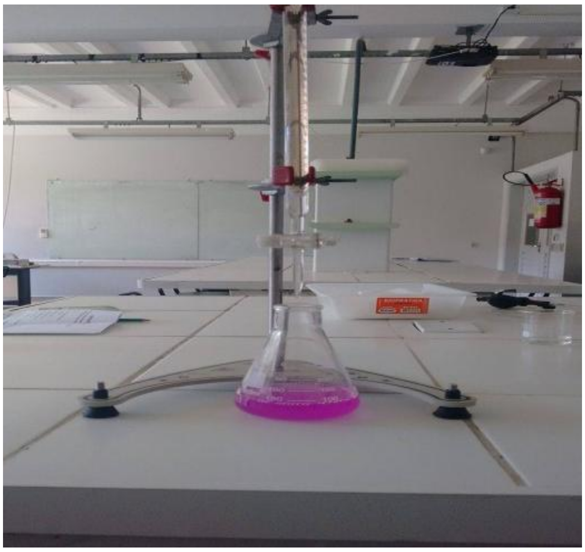
To determine the acid value in the oil, we measured the amount in mg of some base needed to neutralize the free acids present in one gram of oil or fat. Ribeiro and Seravalli(2004) indicate that the state of conservation of the oil is closely related to the origin and quality of the raw material. In addition, Angelucciet al. (1987) report that the high acid content of a crude oil increases the loss of the neutralization and is an indicator of low quality seeds or of improper handling and storage or unsatisfactory processing.

Fatty acids (AG) participate in the constitution of mono-, di- and triglycerides, the main constituents of oils and fats. In fact, fatty acids are carboxylic acids that have long and unsaturated chains, which is a characteristic that differentiates them from the other constituents of this group. Because they are carboxylic acids, fatty acids can be neutralized by a strong base such as sodium hydroxide (NaOH) and potassium hydroxide (KOH).

Oils that are more unsaturated are oxidized faster than less unsaturated oils. As the degree of unsaturation increases, both the rate of formation and the amount of primary oxidation compounds are higher at the end of the induction period (Choe and Min, 2006). The acidity index is a very important factor to be analyzed from the oil, since high acidity can disrupt the result of reactions that make use of it. For its determination, titration was performed, in which a solution of sodium hydroxide (NaOH) was used as titrant and the indicator used was phenolphthalein. The procedure consisted of weighing 7 grams of the oil in a 250 ml Erlenmeyer flask, then adding 75 ml of 95% ethanol and 3 drops of the 1% phenolphthalein indicator. The titration process was done by dripping the NaOH solution until the mixture obtained slightly pinkish coloration for at least 15 seconds. For the calculations, the volume of NaOH spent in the titration per gram of the sample was used. Figures 4 and 5 show the titration process.

Figure 4. *Titration of the Sample*

Figure 5. *End of Titration*



Soaps are produced from oils through saponification reactions, which arealso neutralization reactions. This reaction of the oil with aqueous alkali solution results in the formation of glycerol and a mixture of alkali salts of fatty acids (Ribeiro and Seravalli, 2004). The reaction is exothermic and autocatalytic. Triglyceride is attacked by alkali, releasing glycerin and fatty acids, which are neutralized by the base to form soap (Castro, 2009). The scientific name for the soap is sodium carboxylate, due to its forming reagents, which are esters and sodium hydroxide.

For the production of the liquid detergent from the castor oil, the oil was mixed with ethyl alcohol, potassium hydroxide solution and water in a Becker.

Elaboration of the Prototype

An acid-base reaction is a type of chemical reaction that occurs between an acid and a base and releases certain substrates. Several definitions exist regarding to this type of reaction, and eachprovides alternative concepts for the reaction mechanisms involved and their possible applications. The prototype was produced from acid-base reactions in contact with the detergent produced in order to retain the CO_2 released by the reactions. This type of reaction, in which $CO_2$is released, causes an increase in the pressure of the gas within the solution, which results in a foam. This CO_2 foam, when in contact with natural detergent made with castor oil, increases and becomes more stable, that is, the viscosity of the detergent causes the CO_2 released to be partially trapped.

Prototype Performance Checks

The production of concrete with incorporated air comes about in the following two ways: the first is the use of products added to the concrete mixture, and the second is the use of cement that already has this added feature in its composition. The first methodis the most used, since there may be greater control of the air incorporated with the dosage of the product and the components of the concrete used.

The concrete mixing process is also of great influence to the final content of built-in air. During the mixing time, if the rotation of the concrete mixer is low, the air is not incorporated with full capacity and, if the time is too long, that is, when there is excessive rotation in the concrete mixer, the concrete loses the air incorporated. Therefore, it is necessary that the mixture occurs in optimal time and with the number of rotations considered ideal. For the additives existing in the market, that number is 15 rotations, being able to vary more or less under the analysis of the technical responsible at the time of the execution of the mixture.

To verify the performance of the prototype of the bioadditive incorporating air for concrete, 6 cylindrical specimens 10x20 cm were molded, in which 3 were filled with conventional concrete and 3 with the same concrete with the additive. The trait used was 25 MPa (1: 2.06: 2.64: 0.5). The proportion of additive per m^3 of concrete used was 0.8 L.m-3.

Results and Discussion

Determinations of Seed Moisture Content

The percentage of moisture obtained in the samples is in agreement with the standards, close to the results found by (Souza et al., 2005) (Table 1).

Table 1. *Seed Moisture Content*

Sample	Moisture
n°	(%)
1	7.01
2	6.96
3	6.98
4	6.89
Mean	6.96

Extraction of Castor Oil

In industry, castor oil can be extracted from the whole seed or from a mechanically peeled seed, called a berry. The method used to extract the oil may be cold, hot, or solvent extraction.

Solvent extraction is a more modern procedure than pressing and is used to obtain higher yield and purity than in other extraction processes. Processed seeds are immersed in the specific solvent and the separation is carried out chemically by distillation at special temperatures.Thiscauses only the evaporation of the solvent, not the oil, followed by a filtration process to separate the oil from the solid part of the seed, known as cake. In this case, the oils obtained generally have greater applicability because of their higher quality. Solvent extraction, or liquid-to-liquid extraction, is a chemical procedure in which a solution is mixed with a solvent, essentially immiscible with the first solvent, in order to stimulate aggregation of the solvent with the solute, i.e. the solvent separates the solute from the original blend. Subsequent separations to remove the solvent from the obtained product can be simply performed through heated distillation and vacuum filtration.

After extraction, we calculated a ratio between the mass of the dried seeds used and the mass of the oil obtained. The yield was 39.7%. The values were close to those found by Machado, et al. (1998), who reported values between 44 and 55%. The procedures for extraction were quite satisfactory, as the result presented a value close to those referred in the literature.

Determination of the Acid value of Castor Oil

According to Santos et al. (2001), oils expressed with an acidity of less than 1% are classified as type 1, and when the oil has a maximum percentage of 2.5% free acidity in the analysisit is considered type 3. The determination of the acidity index provides important information in assessing the state of conservation of an oil. Processes of decomposition, either by hydrolysis, oxidation or fermentation, alter the concentration of the hydrogen ions, which is what causes the acidity of some substances to rise.

If fatty acids form the oils and fats in the form of mono-, di-, and triglycerides, a high amount of free fatty acids indicates that the product is in an advanced state of deterioration. The main consequence of this is that the product becomes more acidic. A high acidity index indicates that the oil or fat is suffering breaks in its chain, and releasing its main constituents, the fatty acids.For this reason, the calculation of this index is of great importance in the evaluation of the state of deterioration (hydrolytic rancidity) of a vegetable oil. Each vegetable oil has a characteristic profile of constituent fatty acids.

During the oxidation process of oils, short chain fatty acids appear due to the secondary oxidation of unsaturated aldehydes and other products formed from the breakdown of hydroperoxides.

The acid value is calculated by the volume equation of the titrate by the mass of the sample, see equation 1. The results of the test are presented in Table 2.

$$IA = \frac{V.f.N.M}{P} \quad \text{(Equation 1)}$$

At where:

V→Volume in ml of NaOH spent in the titration
F→ Correction factor of the NaOH solution
N→ Normality of NaOH solution
M→ Result indicator mass (KOH or oleic acid)
P→ Mass in grams of the sample

Table 2.*Results of Acidity Index*

KOH/g of sample	Acid oleic
(mg)	(%)
0.68112	0.3412

Production of a Detergent from Castor Oil

Soaps are organic salts obtained from the reaction between a molecule of triglyceride (fat) and an inorganic base (Atkins and Jones, 2012). This procedure is chemically a hydrolysis reaction in an alkaline medium that createsin the soap in its final process; this reaction is known as saponification.

The soaps are able to reduce the surface tension of the liquids that come in contact, reducing, in this way, the amount of interactions between the molecules that constitute it (Fernandes, 2009). A neutral liquid soap (detergent) was produced based on castor oil (Figure 6).

Figure 6. *Production of the Detergent*

Elaboration of the Prototype

The produced prototype was able to form a microbubble system with the CO_2 released from the acid - base reactions retained inside in a partially stable way (Figure 7).

Figure 7. *Prototype*

Source: Authors

Prototype Performance Checks

According to Kosmatka et al. (2003), several factors can interfere with the incorporated air content.Although the incorporated air content is not the only parameter that should be taken into account, it is the only parameter that can be measured in the fresh state of the concrete.

Concrete made with the bioadditive prototype obtained an incorporated air content of 8.8% (Tables 3 and 4).

Table 3. *Data of Conventional Concrete Made*

Volume	Slump Test	Density
(m³)	(mm)	(m³)
0.00942	10	2183

Table 4.*Concrete Data with Addition of the Prototype*

Additive	Rotating in the concrete mixer	Density	Slump Test	Volume
(l)	(n°)	(m³)	(mm)	(m³)
0.007536	15	1161	22	0.01025

Conclusions

From tests for the determination of the moisture content of castor bean seeds, we found that the samples had the necessary quality for the extraction of the oil. The oil obtained in the laboratory extraction process was adapted to the acid indexes described in the literature. With this being done, it was possible to develop a prototype of an air additive for concrete using a neutral natural detergent based on castor oil, instead of the synthetic compounds that the market has been using. This alternative process minimizes environmental damages of current manufacturing process. The incorporated air content, acquired in this prototype, has not yet reachedthe ideal, although it has been quite satisfactory. Another important point was that it was possible to observe a significant increase in the concrete workability through the Slump Test procedure, which verified that there was a 12mm increase in the concrete abatement that used the prototype. Fostering knowledge and developing innovation for sustainable construction is the guiding point of this project, which aims to establish, together with the demand for a bioadditive, an efficient and economic solution that can replace the existing products in the market.

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