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Disputes over the use of teflon in dentistry

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(Elisa Attardi)

ABSTRACT

Teflon (ptfe) is a widely used material for a wide range of applications thanks to its very stable chemical composition that gives it considerable physical-chemical capabilities such as its great chemical and thermal stability, its low surface energy, insolubility in organic fluids, making it an ideal choice in many areas. However, it would seem that perfluoroacyl compounds (PFC's) are incapable of degrading, demonstrating the tendency to bioaccumulate and biomagnificate. This would make them persistent pollutants in the environment compromising global health.

Since it is also widely used as a medical and dental device, it is necessary to evaluate the risks that choice in the use of this material may result in clinical choices once the behavior of materials containing a high amount of fluorine would seem to interact negatively with materials widely used in medicine, like titanium.

Key words: “teflon”, “ptfe”, “pfoa”, “pfos”, “dentistry”, “titanium”, “implants”.

RESUMO

O Teflon (ptfe) é um material amplamente utilizado para uma ampla gama de aplicações, graças à sua composição química muito estável que lhe proporciona consideráveis capacidades físico-químicas, como a sua grande estabilidade química e térmica, a sua baixa energia superficial, insolubilidade em fluidos orgânicos, sendo assim uma escolha ideal em muitas áreas. No entanto, parece que os compostos de perfluoroacil (PFC) são incapazes de degradar, demonstrando a tendência de bioacumulação, tornando-os poluentes persistentes no meio ambiente, comprometendo a saúde global. Uma vez que também é amplamente utilizado como dispositivo médico e dentário, é necessário avaliar os riscos que uma escolha clínica pode resultar, uma vez que o comportamento de materiais que contém uma quantidade elevada de flúor parece interagir negativamente com outros materiais amplamente utilizados em medicina, como o titânio.

Palavras chaves: “teflon”, “ptfe”, “pfoa”, “pfos”, “medicina dentaria”, “titânio”, “implantes”.

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Ao meu pai.

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I. Introduction

By Roy Plunkett's random discovery in 1938, polytetrafluoroethylene (ptfe) has become a valid choice for a large number of applications. The ptfe commonly known as Dupont's TEFLON, which is the trade name, is a well known polymer for its properties such as chemical inertia, thermal stability and hydrophobicity; desirable characteristics due to its chemical structure that have led this material to be used in a variety of fields (Wikol et al., 2007).

Perfluorated compound (PCF) are chemical compounds made by man that due to their capability, are used in many areas such as industrial and homefield consumption. In recent decades, consumers have embraced these chemicals as important chemical tools for all kinds of household-related processes such as cooking, clothing, furniture, etc (Hekster et al., 2002). Beginning from the end of the years '90, an increasing number of published scientific studies, individualizing the environmental potential risks set by this type of chemical substances, have brought correlated chemical substances to the PFAS to the center of the international public environmental worries (Kallenbor et al., 2004). The distribution and behavior of these substances still requires extensive studies, but substances such as perfluorooctanesulfonato (PFOS) and perfluorooctanoate (PFOA), perfluorinated acids that are PFC degradation products, prove to be more resistant and non-volatile (Ellis et al., 2004). No age - or gender-related differences in PFOS and PFOA concentrations were found in serum specimens. The degree of association between the concentrations of perfluorochemicals varied, depending on the origin of the specimens. These findings suggested the existence of sources with different levels and compositions of perfluorochemicals, and the differences in exposure patterns to these chemicals in the various countries (Kannan et al., 2004). Recent studies have demonstrated their global presence of those chemicals in the environment and it asks for new tools of evaluation as it regards the technical survey and the evaluation of the risks. The unique physical-chemical ownerships of the group of substances are still a great challenge for the environmental scientists and for the authorities of regulation (Kallenborn et al., 2004). In 1998 the TFE has been classified by the International agency for the Search on the Cancer (IARC) as eventually carcinogenic for the human. This was based on animal tests "enough" and "inadequate" (IARC, 1998). In 2003 the European Center for the ecotoxicology and the toxicology of the chemical (ECE-TOC)

substances has published a critical evaluation of the data related to the toxicity and to the ecotoxicity for the TFE (ECETOC, 2003). Although there are evidences that these combinations exist in serum of non-professionally exposed human creatures, the pathways leading to the presence of PFOS and PFOA are not well characterized (Moriwaki et al., 2003). The purpose of this revision has been to present a critical evaluation of the toxicology and ecotoxicology of PCF and to evaluate if the use of the teflon in dentistry is a valid and sure choice, or if this chemical mixture and its by-products can bring to possible cancerous pathologies.

1. Materials and methods

A bibliographic review has been made selecting appropriate scientific information published on the database PubMed, Elsevier and Google Scholar.

n the period between June 2017 and December 2017. Articles have been chosen in English, Portuguese and Italian published in the last 20 years. In total, about 360 articles were found, of which 66 were selected for the elaboration of this thesis.

The keywords used in the research were: telon, ptfe, pfoa, pfos, dentistry, titanium, implants.

II. Development

2.1 Polymer characteristics

Perfluoroalkylated substance (PFAS) is the term depicting a wide range of chemicals containing fully fluorinated carbon atoms of different chain lengths (Armitage, 2006). Polyethylfluoroethylene is a polymer obtained by the polymerization of the tetrafluoroethylene monomer whose structure is: $\text{CF}_2=\text{CF}_2$

This monomer is obtained by a pyrolytic reaction, i.e. a thermo-chemical decomposition process of organic materials obtained by heat application and in the presence of an oxidizing agent. The reaction can be carried out by suspending polymerization or emulsion polymerisation. This is a highly exothermic reaction and there are a few necessary steps to avoid temperatures reaching levels beyond which it becomes explosive by developing tetrafluoromethane and carbon. The synthesis of the ptfé is done by the polymerization of tetrafluoroethylene emulsifying at low temperatures and pressures, this reaction can be described as follows:

In the emulsion, particles of polymer that are dispersed are formed, so the mixture is extracted and undergoes a first coagulation in water and HCl. The filament that is still soft is synthesized, i.e. it is brought in a short time at a high pressure 390°C that secures the wire particles between their contact points. The fact of possessing a chemical structure of only two elements, carbon and fluorine, defines the ptfé as a simple polymer and gives it great chemical inertia. This is due to the fact that these two atoms interact through a very strong bond. The fluorine atoms coil the carbon chain in a rigid manner, this rigidity affects the melting point, making it very high (327°C). The rigidity of the C-F bond causes stiffening of the perfluorocarbon chain and greatly limits the possibility of interaction with other molecules. In addition, the high ionization potential and the low polarizability of the fluorine atom create extremely weak intermolecular interactions, low surface energies and very low refractive indexes. Due to weak interactions, the perfluorated compounds are insoluble in common organic solvents and polar solvents. It is necessary to consider that there are partially fluorinated compounds which therefore contain a hydrocarbon part, thus have hydrogen atoms in their structure and totally fluorated compounds which therefore do not have the

hydrocarbon part. Ptfе is a completely fluorinated compound, this gives the molecule a greater density due to the atomic volume of fluoride. Such chemical inertia combined with low dielectric low and low superficial tension make this material non polar and a good insulator. Furthermore, its chemical conformation has consequences for surface tension and surface energy. Fluorinated polymers are difficult to wet both in organic and aqueous solvents, as they have low solid-liquid interface interactions, resulting in free low energy surfaces. During its emulsion polymerization, the ptfе is made hydrophobic due to the presence of fluorinated surfactants, howsoever there are doubts about the toxicity of certain surfactants such as perfluorooctanated ammonium and other salts of perfluorootanate acid which make some innovations to production technologies necessary (Munaro, 2013). During the manufacture of PTFE, ammonium perfluorooctanoate (APFO) is used as a polymerisation aid. APFO is the ammonium salt of perfluorooctanoic acid (PFOA) and is usually removed during the finishing process of fine powder and granular products. However, it remains in water-based breaking up PTFE products. APFO easily separates to form PFOA in water-based solutions (Sleuwenhoek and Cherrie, 2012) The problem arises when the toxicogenicity of perfluorochymes in humans is still not well known (Harada and Wiebek, 2005) and being products that can not be degraded can stay in the environment for a long time and can also travel distances through water, once these compounds forming teflon like pfoa can be found in consumer access products and the environment (ewg.org). The chemical compounds used for production and content in Teflon can have various exposure media (ewg.org):

Can be accumulated in the environment and found in wildlife (Giesy and Kanan, 2001); Chemical acids belonging to this group on the surface of water (Hansen et al., 2002), as well as in the biota (Tao et al., 2006); Studies have shown that the main means of exposure to pfas are the air, the water to drink (Fromme et al., 2009, Pan et al 2014.,) and that food consumption contributes largely to exposure, especially fish have been declared as the major cause of exposure to pfas for humans (Tittlemier et al 2007; Haug et al., 2010). Their effect on animals that showed hepatotoxicity, immunodeficiency toxicity (Peters and Gonzales, 2011). And in consumer products by exposing humans to serum levels in certain fluorochemical compounds (Hansen et al., 2001). They can be in the air and be respired by entering the body (epa, 1996). Once they enter the body their mechanism of action is still unclear.

2.2 environmental concerns

PFS are of interest, as they can be precursors of poly- and perfluorinated alkyl substances (PFAS), of which several are persistent and are found worldwide in human blood and in the environment (Trier et al., 2010). For the first time, the global environmental distribution of pfos, or fluorinated organic chemical contaminants, is demonstrated through assemblies collected in North America areas in the Great Lakes region, taking into account wildlife tissues and including some bird species and mammals. This study showed how the chemical structure of the compounds caused their bioaccumulability in the environment (Giesy and Kannan, 2001). Pfos had been defined as bioaccumulable and bioconcentrated for studies in blegill sinfish tissues (3M, 2000). Other studies have tested the distribution of pfa through atmospheric transport in various geographic locations and how these acids are dispersed in the environment due to the perfluoroacyl carboxylase emission required by the PTFE thermolysis process (Martin et al., 2003). Beyond of the chemical-physical capacities such as bioaccumulability some of these chemicals among the pfas show to be soluble in water (Pan et al., 2014). The presence of pfas on the surface of water has been demonstrated and described their transport and destiny from the ocean to its boundary boundaries (Hong et al., 2012). Analyzes of perfluorinated acids in water were carried out with sensitive and accurate methods, an ocean survey was conducted in which water samples were collected from selected coastal environments to measure the concentrations of perfluoric acid in surface water (Taniyasu et al., 2003; Yamashita et al., 2003). Two major hypotheses for global PFC transport were proposed. First, neutral and volatile precursors may be subject to long-range atmospheric transport and degradation in remote regions, which would also explain their ubiquitous behavior in the biota according to which some unknown precursors are emitted into the atmosphere and ultimately degrade to Produce PFCAs (Ellis et al., 2004). This hypothesis is supported by the determination of precursor compounds, such as fluorotomeric alcohols (FTOHs), perfluoroalcososulfonamidoethanol, in the Arctic Atmosphere (Nabholtz et al., 1997). The second hypothesis is supported by the Disease that PFC Ions such as PFSA and perfluorinated sulphonated perfluorocarbons (PFSA) exhibit high solubility in water and low pKa values and are thus dissociated to environmentally friendly pH values (Harent rt al., 2009). PFOS ecotoxicological studies have been conducted in several

aquatic organisms under laboratory conditions (3M, 2003; OECD, 2002). PFOS has been shown to be toxic to fish in short-term studies at concentrations below the limit of its freshwater solubility (Yamashita et al., 2005). A large number of global transport hypotheses have been proposed to account for PFCAs present in the Arctic including atmospheric transport of volatile precursors (Wallington et al., 2006) also in ocean transport, marine aerosol and atmospheric transport of PFCAs themselves (Armitage et al., 2006; Prevedouros et al., 2006).

2.3 Mechanism of interaction

Having assessed the trophic relationship of chemical compounds in the environment, it is now necessary to consider the influence they may have on the food diet of the animals, since carbon has been used to quantify overlapping in the food chain in marine organisms (Kelly, 2000). Studies have recently suggested that predators like marine mammals contain concentrates of perfluorinated acids and perfluorinated compounds with higher levels in the banks of the river (Van de vijver et al., 2003). Perfluorooctane sulphonate (PFOS) proved to be the predominant compound by demonstrating a potential capacity to accumulate in the food chain (Kannan et al., 2001). As previously demonstrated, in accordance with their structure, perfluorinated chemicals demonstrate a high bioaccumulation capacity and therefore has a high potential for biomagnification showing little or no capacity to degrade (Key, 1997), but unlike other persistent organic pollutants, due to their surfactant structure these have the ability to bind to blood proteins accumulated in liver of exposed organisms (Van de Vijver et al., 2003). In a study conducted by Kannan et al in 2001, pfos and pfoa have been shown in predatory mammal muscle tissue and it has been shown that pfos has a tendency to link proteins, thus accumulating in the liver. Other studies have been carried out to clarify the hypothesis that the above-mentioned compound can act on the body. It has been demonstrated through studies on rodents that an exposure to pfos may have effects on the liver and subsequently cause liver cell hypertrophy (Butenhoff and Seacat, 2001), a decrease in body weight, triglycerides, and an increase in volume liver (Butenhoff and Seacat, 2001). After the concerns arising from the toxicity tests carried out on rodents

for the potential systemic effects of pfos, the consequences of the accumulation of this chemical in other tissues, such as the brain, have also been studied. Again, pfos exposure decreased the intake of food causing weight loss, influenced external cyclicity, increased serum levels of corticosterone, decreasing leptin concentrations. It has also been shown to be able to influence the neuroendocrine system in rats by increasing the concentrations of norepinephrine in the paraventricular nucleus of the hypothalamus (Austin et al., 2003). Further studies on apes have been aimed at verifying whether a low-level exposure to pfos could give information on possible exposure risks for humans (Seacat et al., 2002). The results showed adverse effects due to exposure to decreased body weight, increased liver weight, lowered serum total cholesterol, lower levels of estradiol, hepatocellular hyperplasia and lipid vacuolation (Seacat et al., 2002). High concentrations of PFAS in the liver were also found in certain species of fish (Sinclair et al., 2005). Studies have shown that perfluorinated acids have the ability to create bonds with peroxisomes, leading to hepatocytic hepatomegaly and proliferation (Lau et al., 2006). This seems to lead to an oxidative damage to DNA as peroxisome proliferation results in overproduction of hydrogen peroxide due to β -oxidation of fatty acids causing an imbalance in the production of hydrogen peroxide (Moody et al., 1991; Kleszczyński 2009) The most significant toxic effects are shown in the decrease in body weight that appears to imply mitochondrial dysfunction (O'Brien and Wallace, 2004; Shabalina et al., 2015). Effects of cytosol acidification have been demonstrated due to the interaction of perfluorochymes with the cell membrane membrane, thus demonstrating effective interaction of these with body cells (Kleszczyński and Składanowski, 2011).

Seeing the effects these chemists demonstrate in the environment (3M, 2003; Armitage, 2010) in wildlife (Giesy et al., 2001) and animals (Austin et al., 2001; Gulkowska et al., 2006), a number of studies have been proposed to evaluate the possibility that bioaccumulative capacity of chemical compounds may also be present on humans (Conigliano et al., 2001; Ehresman et al., 2007), and studies also show an increased risk associated with exposure during TFE synthesis and polymerization processes that would seem to be consistent with animal studies (Consonni et al., 2013).

2.4 risks associated with the presence of fluorides in dentistry

In the biomedical field ptfе is mainly used for artificial tendons and artificial ligaments in the musculoskeletal system, in cardiovascular surgery as polymeric devices, in reconstructive facial surgery, as implant for soft-tissue augmentation (Redboard et al., 2008). Vascular grafts and sutures known as GORE-TEX, its commercial woven form made of expanded PTFE. These graftscan be designed in a wide range of configurations including straight, tapered and bifurcated (Bidanda and Bartolo, 2008). Expanded ptfе is a microporous membrane used in some general, medical and pharmaceutical applications. Its manufacturing process starts with pure ptfе, then a lubricating agent is added so that the powder forms a paste and can be extruded into sheet form (Wikol et al., 2008). In dentistry this polymer is also used as a membrane for guide bone regeneration as a non reabsorbable membrane (Zhang, 2013; McAllister and Haghightat, 2007), brackets and teflon-coated archwires (Farronato et al., 2011), in endodontics can be used as temporary filling when it is not possible to restore the tooth immediately. (Chiodera and Pavolucci, 2016). Teflon can be used in prosthodontics for isolating intermediate elements in bridges, in the cimentation procedures to reduce the excess of the material. In implant prosthesis is an excellent material to isolate the access hole; Teflon is inserted into the hole and then compressed. It is also widely used in cemented prostheses above the abutment. In the prosthesis screw about 1.5 mm from the occlusal surface and cover access with composite or the preferred material. Forward, thanks to the ability to be a very opaque material is used as a cover for camouflaging gray metal shade (Chiodera and Pavolucci, 2016). Since the work made by Branemark, titanium and its alloys were the first materials chosen for fabricating implant and infra-structures prosthetic systems in oral rehabilitation supported by implants. Titanium and its alloys have a significant clinical performance due to their properties, such as low density, low elastic modulus, high mechanical strength, high corrosion resistance and excellent biocompatibility (Juanito et al., 2016). Pure titanium and Ti-6Al-4V are still the most used ones for biomedical applications among the titanium alloys and in dentistry it has demonstrated an excellent biocompatibility and valuable mechanical properties (Niinomi, 2003). The principle of the osseointegration founds on a direct structural and functional connection between the living bone and the surface of a titanium implant that receives the functional load. Titanium is an excellent material for osteointegration

because it combines the characteristics of superficial energy with good biocompatibility and mechanical strength. The long term success of dental implants is closely linked to their osteointegration (Souza et al., 2015). When this material is in contact with water or air, a thin layer of titanium oxide (TiO₂) is formed to prevent the release of ions in the body. However, when titanium is exposed to adverse conditions such as pH changes, the presence of fluorides, thermal changes, biofilm and saliva; this oxide layer degrades permitting the release of ions resulting in changes in the surface of implant (Faverani et al., 2013). So must be aware that the stability of the oxide film depends on the corrosivity of the environment in contact with the titanium and in presence of fluorides titanium may corrode, especially solutions containing a considerable F⁻ concentration or in acidic fluoride solutions, hydrofluoric acid (HF). Those seems to be able to promote the localized corrosion of titanium. (Souza et al., 2012). Corrosion of metal is critical because it can negatively affect the biocompatibility and mechanical integrity of implants. Corrosion and surface oxide film dissolution are two mechanisms for introducing additional ions into the body and an extensive release of ions from implants can result in adverse biological reactions, thus causing the mechanical failure of the device (Marino and Mascaro, 2004). So an high concentration of fluorides negatively influences the corrosion resistance of titanium and its alloys because in an aqueous solution it promotes an association between H⁺ and F⁻ ions that form hydrofluoric acid (HF), corrosive to many materials, including titanium. Precisely because the strong responsiveness of HF molecules is extremely aggressive in relation to metal materials, glass ceramics or living tissue, the corrosion resistance of Ti and its alloys depends on the concentration of fluorine and the pH of the surrounding solution (Juanito et al., 2016). For example, in an in vitro study done by Souza in 2013 localized corrosion was detected on titanium surfaces in a solution containing 12300 ppm F⁻ at pH 6.5 due to the pitting corrosion process. It must be also take into consideration the distribution of stress around the dental implant once it depends on a large number of other biomechanical factors, such as the properties of structural materials, the geometry of the structural components, the characteristics of the surface, the contact geometry, magnitude and direction of the masticatory load, the distance between the abutment and the implant, and between the abutment and crown, that are important to prevent micro-movements and accumulation of corrosive substances between moving parts (Souza et al., 2010). The degradation of titanium seems to cause four main phenomena that is:

corrosion processes affecting mechanical integrity of structural materials; change in the electrochemical reactions; increase of roughness; and release of ions and metallic particles that are deposited on surrounding tissues penetrating across tissues and the bloodstream that can promote local or systemic toxicity (Juanito et al., 2016). Corrosive substances from the diet, human saliva and oral biofilms can accumulate in peri-implant areas, thus promoting the corrosion of metallic surfaces (Souza et al., 2012). This is defined as a combined wear and corrosion process known as tribocorrosion, the result of the interactions between mechanical, chemical and electrochemical processes that occur in contact with surfaces undergoing relative movement and can cause irreversible transformation of the materials. That is why a release of metal ions and oxide particles can induce chronic peri-implant inflammation because they act as foreign bodies on liver tissues by stimulating the attraction of macrophages and T lymphocytes from the immune system. Chronic inflammation of peri-implant tissues leads to osteolysis and subsequently a bone loss that supports implant-supported prostheses and accumulation of corrosive substances in such areas increases titanium corrosion while chewing-up loads intensify osteolysis (Souza et al., 2012). Other studies (Cruz et al., 2013; Oshida et al., 2005) have mentioned corrosion of titanium and its alloys after exposure to therapeutic agents such as fluorides and hydrogen peroxide showing that the release of Ti ions and particles from CP-titanium or Ti, Al, V ions from titanium alloys to the surrounding tissues can stimulate an initial inflammatory response, as a results of it degradation progress. The presence of metal ions and released particles is considered a risk factor for the development of peri-implant inflammation (Juanito et al., 2016) Consequently, the spread of Ti, Al, V in the bloodstream can lead to cytotoxicity, mutagenicity or carcinogenic reactions, considering previous studies in the literature (Brogghini et al., 2006). Moreover other studies showed that the particles of Ti that wer detected in the peri implantit tissue can also be found in organs like liver, kidney and lymph nodes (Sjogren et al., 2000; Liu et al., 2013). Thus, patients who wear titanium based implant and prostheses shoul be informed on negative effects of high F⁻ concentration agents associated with acidic substances once it can determing the succes of a long term success of the oral rehabilitation structures. And it is of great importance that dentists check the clinical history of the patients in order to evaluate the presence and composition of dental implants and prostheses (Juanito et al., 2015).

III. Discussion

In this paper we have highlighted how teflon is widely used in a large range of applications. Due to its stability, which is conferred by its strong chemical structure, ptfe has a remarkable chemical inertia, established thermal and hydrophobicity (Wikol et al., 2007). The polymer's ability is attributed to its structure consisting only of two molecules that joining in such a strong and stable ties do not interact with other elements, creating very strong intermolecular interactions (Munaro, 2013). These are the main reasons why this manmade material produced by chemical process is present in everyday uses materials (Heckser et al., 2002) but also in medical fields (Readboard et al 2008; Bibanda and Bartolo, 2008) for which a new form has also been created, namely expanded ptfe and also this is known as medicine, pharmaceutical and general use material (Wikol et al., 2008). Even in dentistry, this material, as we have just seen, is used for various clinical protocols (Chiodera et al., 2016) and in surgical procedures as a membrane (Zhang et al., 2013) and as proper material (Farronato et al., 2011).

As previously demonstrated, the ptfe is generated by the polymerization of the tfe in the presence of oxidizing agents. The polymer has a very strong chemical structure as it consists only of two molecules, carbon and fluorine, and this is what gives the product such characteristics that make it the ideal choice.

Moreover, the fact that it is a fluorine-containing compound, an extremely electronegative element, gives the molecule a high density and makes it insoluble in most organic solvents (Munaro, 2013). The products that are used for the polymerization process that leads to PTFE's formation, kown as APFO and PFOA, have shown the ability to take cytotoxic behavior as their interactions in the human body are not yet very clear (Wiebek and Harada, 2005), as they also demonstrated their ability to be non-degradable and accumulate in the environment by propagating through the same (ewg.com). As we have previously seen, the presence of these chemical compounds was found in the environment and wildlife (Giesy and Kannan, 2001); as well as in the air and drinking water (Fromme et al 2009, Pan, 2014) and in fish exposing humans to PFAS (Haug et al., 2010). In addition, animals also showed systemic cytotoxicity effects (Peters and Gonsales, 2011). Thus, pfs, or substances containing flourous molecules, have become a source of interest when they are PFSA precursors and have shown their persistence in the environment in lakes areas as in studies conducted in

North America, where tissues of various tissues were analyzed (Gyesi and Kannan, 2001), which were thus termed bioaccumulable and bioconcentrated (3M, 2000). Many environmental studies has been made to evaluate the concentration of PFC in the environment and the ability of these to be transported from one place to another through water and air diffusing into the atmosphere, affecting the health of the present microorganisms , animals, and finally man (Taniyasu et al., 2003; Yamashita et al., 2003); (Ellis et al., 2004); (Yamashita et al., 2005); (Armitage, 2006; Prevedouros et al., 2006). With regard to the highly resistant chemical structure of these chemical compounds, it was necessary to study, with other studies, the consequences that these may have on the diet of marine animals once they are closely related to the environment (Kelly et al., 2000), since perfluorinated chemicals have been shown to be bioaccumulable and have biomagnification power once they can not be degraded (Key, 1997); and that, unlike other chemical compounds, they have the ability to attach to the blood protein accumulated in the liver of the exposed organisms (Van de Vijver et al., 2003). From this point many authors have shown interest in conducting further studies with the aim of clarifying what the effects of PFOS and PFOA on the living organisms could really be: Butenhoff and Seacat in 2001 have demonstrated a liver cell hypertrophy, a decrease in weight with increased liver volume of rodents exposed to compounds. Austin et al., 2003, attempted to demonstrate a possible influence of exposure to compounds with an increase in serum levels of corticosterone and a decrease in leptin levels. It has also been shown to be able to influence the neuroendocrine system in rats by increasing the concentrations of norepinephrine in the paraventricular nucleus of the hypothalamus. Others studies shows significant toxic effects causing the decrease in body weight that appears to imply mitochondrial dysfunction (O' Brien and Wallace, 2004; Shabalina et al., 2015); even effects of cytosol acidification have been demonstrated due to the interaction of perfluorochymes with the cell membrane (Kleszcyski 2007, 2011). Considering, therefore, the capacity of these products in the PTFE to bioaccumulate and biomagnification (3M, 2000) remaining in the tissues, as shown by the above mentioned studies, it is necessary to pay attention to the reactions of the elements to which they come into contact, especially if they are used for purposes of medical use. As titled in the previous paragraph, titanium is now widely used in dental care for oral rehabilitation due to its properties such as biocompatibility, low density, low elastic modulus, high mechanical strength and high corrosion resistance (Juanito et al., 2015). It also demonstrates a high degree of

osteointegration, immeasurable ability of the material for proper long-term rehabilitation (Souza et al., 2015). However titanium seems to react negatively to certain stimuli that determine the change in its surface structure, such stimuli as pH change, fluoride and thermal changes, as well as oral biofilm and saliva; seem to be capable of causing the degradation of the titanium oxide layer present on its surface (Faverani et al., 2013). This layer can in fact protect titanium from corrosion risk once it has been shown that there is a real possibility that this may occur in solutions where the concentration of fluorine ions is high (Souza et al., 2012). This happens because a high concentration of fluoride in aqueous solutions promotes the association of H⁺ and F⁻ ions, forming the hydrofluoric acid (HF) that has the ability to degrade titanium. The titanium corrosion resistance also depends on other factors, since HF molecules act aggressively on metallic materials, so the fluorine concentration in the salivary and its pH are significant (Juanito et al., 2016). Its intensity plays an important role in this process, since biomechanical factors such as the geometry of the structural components, the contact surface and the adaptation present between the various components may affect the micromovement made by the implant causing accumulation of corrosive substances in the peri-implant area (Souza et al., 2010). When the TiO₂ layer is degraded and the corrosive substances are accumulated in the peri-implant area, this causes corrosion of the metal surface. This is a combined process known as tribocorrosion and is the result of chemical, mechanical and electrochemical processes that lead to irreversible transformation of the material. This results in the dispersion of metal ions and oxide particles that can lead to a chronic inflammatory response (Souza et al., 2012). In areas of implant-abutment connection adverse reactions can occur due to biological causes, such as increased microlinkage, gingivitis, and bone loss; or mechanical causes such as an increase in the incidence of rotation of the abutment and breakage, screw loosening, preload reduction that may occur when the implant-abutment interface is not well adapted (Kano et al., 2007). The microgap present in the implant interface allows microorganisms to proliferate near the junction epithelium causing bone resorption of about 2mm apical to the microgap (Kano et al., 2007). It is always necessary to keep in mind that the implant in the oral cavity is continuously exposed to saliva in the gut and may act as a weak electrolyte, modifying its pH depending on innocent factors. This could cause electrochemical corrosion of titanium alloys caused by the electrochemical nature of the saliva that could cause the release of corrosion products in the body (Mathew et al., 2012). Signs of corrosion on the surface

near the slopes have been observed, which have shown both mechanical change and chemical influence on degradation. This would seem to demonstrate how simultaneous wear and corrosion actions can affect overall plant performance (Vynar et al., 2011). During mastication, the dental implant is exposed to both axial and lateral movements, in addition to the corrosive environment. All forces under dental implants generate micromovements on implant / pillar, abutment / crown and implant / bone interface. Each time the two surfaces rub against each other, their passive protective film can be removed leading to surface corrosion and possible release of corrosion products into the system. These corrosion products could cause inflammatory reactions that would cause the release of inflammatory mediators from macrophages, leading to bone resorption (Mathew et al., 2012). This leads to the fatigue and wear of the contact materials and to the abutment screws scoring depending on the direction and the amplitude of the loads. The rate of wear of structural materials can be greater when there is a big difference in the hardness between abutment and implant or between abutment and crowns. Titanium friction due to micromovements occurring at these joints, probably influenced by fluorinated compound, can dislodge the TiO₂ protective film leading to a loss of material and possible mechanical failure in the dental implant, abutment and prosthesis. In addition, wear may occur as a result of the abrasion due to hard particles from food intake or brushing of the teeth. In addition, corrosive substances from food models, human saliva and oral biofilms can accumulate in perimplant areas, favoring corrosion on metallic surfaces (Sousa et al., 2012). Chronic inflammation of perimplant tissues leads to osteolysis and therefore to bone loss that supports implanted prostheses. This can be considered as a self-sustained system because corrosion can be accentuated by the oxidative species released by the immune system. Accumulation of corrosive substances in these areas also increases titanium corrosion while chewing-up loads intensify osteolysis (Sousa et al., 2012).

IV. Conclusions

It can be stated from the foregoing in this paper that:

- Teflon's chemical structure makes it an ideal material for a variety of uses, but its manufacturing process would seem to be able to cause environmental risks in accordance with its bioaccumulation and biomagnification capabilities;
- The distribution of ptfе by-products has been found in the global environment in the form of contaminants that pollute the water, and can thus affect the wildlife and the food chain;
- Due to the chemically inert structure of the chemical components mentioned, the presence of these in the living organisms exposed, with the consequent impairment of the normal functioning of the vital organs;
- High percentage of fluoriferous compounds seem to interfere negatively with the titanium used in implanted prostheses, which could compromise its durability in patient rehabilitation.

However, it would be necessary to carry out studies to better understand and evaluate the risks associated with the use of ptfе and degradation of titanium and its alloys.

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