Guest Editorial

Nomen est omen - the difficult scientific classification of materials

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Dear readers,

Names are used to identify and classify. Your family name, surname and birthday are together an excellent identifier. I know another dentist named Jean-François Roulet in Brazil; however, his birthday is different. In the modern world, this may be replaced by a number such as the Swiss AHV-number = Army identification number, which is derived from the person's name and birthday, or in the USA the Social Security number [1]. In science, names are used to classify as well. Examples are "mammals" (a warm-blooded vertebrate animal of a class that is distinguished by the possession of hair or fur, the secretion of milk by females for the nourishment of the young, and (typically) the birth of live young), "fish" (a limbless cold-blooded vertebrate animal with gills and fins and living wholly in water), or "metal" (a solid material that is typically hard, shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity). However, names may be used as well to deceive or hide something. Examples are "Deutsche Demokratische Republik", which in reality was a State that had disabled all democratic functions and was governed strictly top-down. Other (current) examples are the fancy term "military operation" instead of "war," and, in dentistry, "Artglass" as a member of the class "Polyglass." "Artglass" was a light/heat cured resin composite produced to veneer metal crowns and fixed dental prostheses. The standard of care at the time was porcelain fused to metal or heat-cured PMMA, the latter having a very bad reputation due to its poor performance. Marketing must have known that it would be difficult to sell a resin-based material to the dental technicians. So, the class "Polyglass" was created with the argumentation that the polymerized resin matrix is amorphous (no crystalline structure), which in chemistry can be named vitroid (= like glass) and the fillers are glass particles; ergo, a lot of dental materials can be named "Polyglass." Thus, the buyer of "Artglass" did not get any hint that he/she was buying a resin composite [2].

Lately, I participated in an annual meeting of a professional association where a Professor used the term "Resin Matrix Ceramics" to refer to a ceramic classification. I personally have a big problem with this term and it made me get back to a dormant project of mine. Why? Because scientists in our research area are following the names and classifications that have been formulated with sales in mind [3].

Let's look at the definitions: composite means made out of various parts. This means that the material is made out of two or more distinct phases. For the resin composite, these are unpolymerized or polymerized resins also labelled as the continuous phase (matrix) and the other phases (fillers) which are usually dispersed in the matrix [5]. Resin composites are not the only composites used in dentistry. For example, some impression materials are usually filled and, thus, comply with the term composite. Dental Ceramics, a ceramic is a manmade hard, brittle, heat-resistant, and corrosion-resistant material made by shaping and then firing an inorganic, nonmetallic material at a high temperature, or simpler nonmetallic inorganic materials produced by firing at a high temperature to achieve desired properties [2]. Dental ceramics are either glass-based with reinforcing crystals (leucite, lithium disilicate) or polycrystalline (Zirconium oxide).

Based on these definitions, a "resin matrix ceramic" is a contradiction per se, since resin is neither inorganic nor heat resistant.

This confusion started when 3M company named their composite CAD-CAM block with a composition very close to their direct resin composite Filtek Supreme, but heat-cured only, Lava Ultimate. Since Lava at the time was 3M's brand name for their ceramic line, the name Lava Ultimate suggests ceramic. In 2015, Gracis et al [3] published a ceramic classification in which they created a category "resin-matrix-ceramics" well knowing that this contradicted the correct definition of ceramic cited above! They described it as "materials with an organic matrix highly filled with ceramic particles." This alone is a scientific sin, because resin composites fit in perfectly in this definition. To make matters worse, they created three subcategories: "resin nanoceramic;" "glassceramic in a resin interpenetrating network;" and "zirconia-silica ceramic in a resin interpenetrating

matrix" - using the companies' marketing descriptions. Mainjot et al (2016) stated that such blocks are resin composites, but suggested that the resin composite class of CAD-CAM blocks should be divided into two subclassifications depending on their microstructure: "with dispersed fillers" or "with polymer infiltrated ceramic matrix" [4]. In my opinion, the real culprit is the American Dental Association (ADA) which in 2013 changed in the Code on Dental Procedures and Nomenclature (ADA 2013) the definition of ceramic for coding to: "pressed, fired, polished or milled materials containing predominantly inorganic, refractory compounds – including porcelains, glasses, ceramics, and glass-ceramics." With this, any indirect composite restoration could be classified as a ceramic restoration. The only reason for this, in my opinion, is that it is $-driven. As a consequence, Lava Ultimate was advertised as "can be coded as ceramic." It is understandable that many customers thought it is ceramic.

Unfortunately, the academic world followed by creating a big confusion. On July 1st, 2021, I searched the Internet for Lava Ultimate; the query produced 307 hits, out of which 297 were further analyzed. I checked in every paper if Lava Ultimate was used and how the authors characterized or classified it. First, I checked if there was a characterization table, and if there was no table, I read the Introduction and the Materials and Methods sections to see how the material was described. 135 times terms classified it as ceramic, with "resin nanoceramic" being the most frequently used (98x). 131 times classified it as a composite, however, only 23 times the material was correctly named "resin composite" or "composite" (19), not classified, brand name (18x), and "composite resin" (17). After these 4 terms, there were 48 terms that, with lots of benevolence, could be summarized as resin composite. Eight names I found were neither composite nor ceramic. This is a clear indication that the authors did not really know what the material was. Here are just a few examples: resin CAD-CAM blocks, Polymer-based blocks, compact filled composite, multiphase resin composite blocks, nanoparticle polymerized resin composite, multiphase resin CAD-CAM material, etc. The damage done by poorly naming and disclosing the composition of a material is obvious.

Seeking transparency/clarity, I am asking manufacturers to be correct in naming and disclosing what is inside and I am asking my publishing and teaching colleagues not to disseminate the marketing stories and to stick to sound scientific terminology. Lava Ultimate is not a ceramic as well as all the blocks that contain resins, even if the inorganic part is connected as a network or the resin is much better polymerized than the ones in resin composites after direct application. They are all resin composites.

Sincerely yours,

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