

**PRINTABLE WAX, METHOD OF PRINTING, AND METHOD FOR FLOW
VISCOSITY CONTROL**

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of Singapore application No. 10202300398R filed on 16 February 2023, the contents of it being hereby incorporated by reference in its entirety for all purposes.

TECHNICAL FIELD

[0002] The present disclosure generally relates to a method of preparing a printable wax with improved viscosity, and a method of printing a 3D dental structure using the printable wax. In particular, the present disclosure relates to a method of preparing a printable wax with improved viscosity for use in 3D printing in dentistry, and a method of printing a 3D dental structure using the printable wax and a customized extrusion part for dispensing the printable wax for 3D printing.

BACKGROUND

[0003] Digital dentistry is now transforming almost every aspect of professional oral care in current dentistry. However, in almost all current dental clinics and labs, dental wax is still processed manually as there is no solution to 3D printing for dental wax. The main gap arises from the fact that most printable wax-like materials require an extremely long time to melt and cast into shapes, which is not suitable for clinical applications, and traditional dental wax has low viscosity in its melting state, making it challenging to achieve fast printing in the lab.

[0004] Ageing population and rising oral health awareness have been driving the dental treatment demands. In dentistry, restoration of teeth or other oral tissues are the most common dental procedures that require customized fabrication. These prosthodontic procedures, such as the fabrication of crowns, dentures, and implants, are performed based on the recording of

patients' dental anatomy at the clinics. Currently, various dental waxes are widely used in the clinics to fabricate artificial restoration of soft and hard tissues of the oral cavity. Particularly, modelling waxes are widely utilised in various applications. They are employed in the formation of wax patterns, utilised in dental laboratories to box impressions before casting with gypsum. Additionally, they serve as a foundational base plate for registering jaw relationships, as a casting wax for establishing minimum thickness in specific areas, and as a material for building denture models in the denture casting process. Moreover, modelling waxes also function as corrective impression waxes, facilitating the contact and registration of detailed soft tissue information. However, at present, most of the biting blocks are handmade by dentists in the clinics (see FIG. 1). This manual process comes with several drawbacks. Firstly, the handmade process can result in contamination with pathogenic microorganisms, including bacteria, viruses, and fungi, introduced through handling and environmental exposure. Secondly, the manual procedure demands a significant amount of the dentist's time to achieve a biting box that fits well with the patient's dental anatomy, often requiring multiple trials. Thirdly, the frequent insertion and removal of the biting box from the patient's mouth may further contribute to contamination, involving exposure to the patient's saliva and/or blood and the surrounding environment.

[0005] Digital dentistry is becoming more and more popular among dental professionals as it provides obvious benefits to dentists and patients. For example, digital solutions are designed to be user-friendly and fit easily into any dental practice. Digital dentistry offers dentists the capability to complete the entire dental process in a single visit for the patient, a stark contrast to the 2 to 3 weeks typically required for traditional impressions. The use of digital technology ensures a low likelihood of correction, eliminating unpleasant surprises for patients. With the rapid advancements in 3D printing technologies and their practical applications in dentistry, the fast and straightforward operation for denture fabrication is anticipated to significantly expedite

the entire dental restoration process with enhanced accuracy. Despite these advancements, it is noteworthy that many clinics continue to rely on the traditional handmade process for various dental wax models. This preference stems from the existing gap between the capabilities of current 3D printing processes and the specific requirements of dental clinics.

[0006] There are three main 3D printing technologies that can be used to make wax patterns. Vat polymerization printing technologies, such as stereolithography (SLA), masked SLA (MSLA), or direct light processing (DLP), which are the most popular technologies to create finely detailed models. However, these processes work with many chemicals and some post-processing steps, making it impossible to be used in clinics.

[0007] Material jetting, another 3D printing technology capable of printing wax-like materials, also employs various types of chemicals in its process. A critical drawback is that both the vat polymerization and material jetting processes require an extremely long time to build a single denture model, often exceeding several hours. This renders them less viable for patients, as waiting for such extended durations at dental clinics may not be practical.

[0008] Wax-like models can also be created using a classic Fused Deposition Modelling (FDM) 3D printer with a specialized wax-like filament, allowing FDM printers to produce precise wax structures swiftly and cleanly in clinical settings. However, a limitation arises as most of the materials available in the current market are polylactic acid (PLA)-based materials. While these wax materials are well-suited for industrial model design and casting purposes, they fall short of meeting the specific requirements for dental applications. This is primarily due to their high softening temperatures, typically ranging from 140 to 240°C.

[0009] It is therefore desirable to provide a method of preparing a printable wax suitable for 3D printing in dentistry, and a method of printing a 3D dental model using the printable wax, which seek to address at least one of the problems described hereinabove, or at least to provide an alternative.

SUMMARY

[0010] In one aspect of the present disclosure, there is provided a method of preparing a printable wax with an improved viscosity for use in 3D printing in dentistry. The method comprises heating a dental wax to melt the dental wax; adding a copolymer or a surface modified nano filler to the dental wax in an effective amount to tune the flow viscosity of the dental wax to a desired viscosity while the dental wax is still heated; subjecting the dental wax to vigorous stirring to disperse the copolymer or the surface modified nano filler well in the dental wax; and allowing the dental wax to cool down, resulting in a printable wax with improved viscosity for fast 3D printing.

[0011] In some embodiments, the viscosity of the dental wax is tuned to 0.1 to 200 Pa·s or 10 to 100 Pa·s.

[0012] In a second aspect of the present disclosure, there is provided a printable wax for use in printing 3D dental structure. The printable wax comprises a dental wax, and a copolymer or a surface modified nano filler, wherein the printable wax has a viscosity ranging from 0.1 to 200 Pa·s or 10 to 100 Pa·s.

[0013] In a third aspect of the present disclosure, there is provided a method of printing a 3D dental structure. The method comprises introducing a printable wax of the present disclosure into a syringe pump; heating the printable wax in the syringe pump using a heating element that wraps around the syringe pump; controlling the temperature of the printable wax in the syringe pump; and commencing printing of a 3D dental structure when the temperature of the printable wax reaches its melting point.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Various embodiments of the present disclosure are described hereinbelow in the detailed description with reference to the following drawings:

FIG. 1 is an image illustrating the prior art of a handmade bite wax for box impressions.

FIG. 2 illustrates the side view of a customized extrusion part of a syringe pump for wax 3D printing.

FIG. 3A and FIG. 3B are graphs showing the comparison of complex viscosity of the neat dental wax and the modified dental wax, modified with (A) surface modified nano filler; and with (B) copolymer.

FIG. 4A and FIG. 4B are images illustrating the successful 3D printing of wax structures using (A) the dental wax modified with copolymer; and (B) the dental wax modified with surface modified nano silica.

DESCRIPTION

[0015] The following description sets forth exemplary methods, parameters, and the like. The embodiments are described in sufficient detail to enable those skilled in the art to practise the invention. Other embodiments may be utilized, and structural and logical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

[0016] Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0017] In the context of various embodiments, the articles “a”, “an” and “the” as used with regard to a feature or element include a reference to one or more of the features or elements.

[0018] In the context of various embodiments, the term “about” or “approximately” as applied to a numeric value encompasses the exact value and a reasonable variance, e.g. within 10% of the specified value.

[0019] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0020] By “comprising” it is meant including, but not limited to, whatever follows the word “comprising”. Thus, use of the term “comprising” indicates that the listed elements are required or mandatory, but that other elements are optional and may or may not be present.

[0021] By “consisting of” is meant including, and limited to, whatever follows the phrase “consisting of”. Thus, the phrase “consisting of” indicates that the listed elements are required or mandatory, and that no other elements may be present.

[0022] In one aspect, the present disclosure relates to a method of preparing a printable wax with improved viscosity. The method comprises using a copolymer with both polar (hydrophilic) and non-polar (hydrophobic) segments or a surface modified nano filler to improve the complex viscosity of a dental wax, making the dental wax suitable for fast dental wax 3D printing, enabling the efficient and precise fabrication of dental structures.

[0023] In some embodiments, the method comprises heating a dental wax to melt the dental wax; adding a copolymer or a surface modified nano filler to the dental wax in an effective amount to tune the flow viscosity of the dental wax to a desired viscosity while the dental wax is still heated; and subjecting the dental wax to vigorous stirring to disperse the copolymer or the surface modified nano filler well in the dental wax; and allowing the dental wax to cool down, resulting in a printable wax with improved viscosity for fast 3D printing.

[0024] The term “dental wax” as used herein refers to a malleable, soft, and pliable material utilised in dentistry for various purposes. It may come in different forms and utilise in a range of dental applications. Some common types of dental wax include, pattern wax, processing wax

and impression wax. Some examples of pattern wax include, but are not limited to, inlay wax, modelling wax, milling wax, base plate wax and wax rim. Some examples of processing wax include, but are not limited to, sticky wax, utility wax, boxing and beading wax, and block-out wax. Some examples of impression wax include, but are not limited to, corrective wax and bite registration wax. The type of dental wax to be employed depends on the type of dental structure that is to be fabricated.

[0025] In some embodiments, the dental wax is heated to its melting point to trigger the melting process. The temperature of the heating process varies depending on the type of wax utilised, as different waxes may have distinct melting points. In some embodiments, the dental wax is heated to a temperature ranging from 50 °C to 110 °C.

[0026] In some embodiments, the copolymer or the surface modified nano filler is added to the dental wax when the dental wax is 95 to 100% melted, 98 to 100% melted, or fully melted. In some embodiments, stirring begins during the melting process, i.e. while the dental wax changes from solid to liquid state. The stirring continues while the copolymer or the surface modified nano filler is added to the dental wax. In some embodiments, the dental wax is stirred at a speed ranging from 500 to 1000 rpm.

[0027] In some embodiments, the copolymer has a hydrophilic moiety and a hydrophobic moiety. The purpose for having a hydrophilic moiety is to enhance molecular interactions, consequently increasing the viscosity of the printable wax. The hydrophobic moiety enhances the interface interaction between the copolymer and the wax particles. This helps to facilitate the dispersion of the wax particles while retaining the inherent properties of the wax. In some embodiments, copolymer with certain ratio of the polar segment is required. In some embodiments, the molar ratio of the polar moiety (hydrophilic) to the non-polar (hydrophobic) moiety is around 0.4 to 0.6.

[0028] In some embodiments, the copolymer has a molecule weight ranging from 1000 to 20,000 or from 1000 to 10,000.

[0029] In some embodiments, the copolymer is selected from the group consisting of poly(ethylene-co-vinyl acetate)s (PEVA), poly(ethylene-co-methyl acrylate) (PEMA), poly(ethylene-co-acrylic acid), poly(vinyl alcohol-co-ethylene), and poly(ethylene-co-ethyl acrylate).

[0030] In the embodiment where the copolymer is poly(ethylene-co-vinyl acetate), the vinyl acetate content (wt%) ranges from 5 to 50 wt%, preferably from 20 to 40 wt%.

[0031] In the embodiment where the copolymer is poly(ethylene-co-methyl acrylate), the content of methyl acrylate ranges from 5 to 60 wt%, preferably from 15 to 30 wt%.

[0032] In the embodiment where the copolymer is poly(ethylene-co-acrylic acid), the content of acrylic acid ranges from 5 to 30 wt%, preferably from 5 to 20 wt%.

[0033] In the embodiment where the copolymer is poly(vinyl alcohol-co-ethylene), the content of vinyl alcohol ranges from 20 to 80 wt%, preferably from 30 to 50 wt%.

[0034] In the embodiment where the copolymer is poly(ethylene-co-ethyl acrylate), the content of ethyl acrylate ranges from 5 to 40 wt%, preferably from 10 to 20 wt%.

[0035] In some embodiments, the viscosity of the dental wax is improved by adding surface modified nano filler to the dental wax. Neat nanoparticles are difficult to be miscible with most dental wax and therefore, surface modification is required. In some embodiments, surface modification is achieved using chemical method, by modifying the nano filler with one or more functional silanes. Example of some functional silanes include, but are not limited to, acetoxymethyldimethylchlorosilane, acetoxymethylmethyldichlorosilane, acetoxymethyltrimethoxysilane, acetoxymethyltriethoxysilane, N-(3-(Trimethoxysilyl)propyl)acrylamide, (2-Acryloxyethoxy)trimethylsilane, (3-acryloxypropyl)methyldichlorosilane, 3-[dimethoxy(methyl)silyl] propyl acrylate, 3-

(trimethoxysilyl)propyl acrylate, 3-(2-aminoethylamino)propyltriethoxysilane, and (3-aminopropyl)triethoxysilane.

[0036] In some embodiments, the nano filler or the surface modified nano filler is an inorganic nano filler, or an inorganic surface modified nano filler, respectively. Some examples of inorganic nano fillers include, but are not limited to, nano silica, nano titania, nano aluminium oxide and nano zinc oxide.

[0037] In other embodiments, the nano filler or the surface modified nano filler is an organic nano filler or an organic surface modified nano filler, respectively. Some examples of organic nano fillers include, but are not limited to, chitosan, cellulose, and carbon nanotubes.

[0038] In some embodiments, the surface modified nano filler has an average particle size ranging from 2 to 500 nm, 2 to 100 nm, or 2 to 50 nm.

[0039] In some embodiments, the tuning of the flow viscosity of the dental wax involves adjusting the amount of the copolymer or the surface modified nano filler added to the dental wax. In some embodiments, the copolymer is added to the dental wax in an amount ranging from 0.1 to 50 wt% or 25 to 50 wt% based on the total amount of the dental wax used, for adjusting the viscosity of the dental wax to fall within 0.1 to 200 Pa·s or 10 to 100 Pa·s. In some embodiments, the surface modified nano filler is added to the dental wax in an amount ranging from 0.1 to 50 wt%, 0.1 to 33 wt%, or 20 to 50 wt% based on the total amount of the dental wax used, for adjusting the viscosity of the dental wax to fall within 0.1 to 200 Pa·s or 10 to 100 Pa·s. The viscosity of the dental wax is modified to prevent dripping of the dental wax during 3D printing.

[0040] After the copolymer or the surface modified nano filler is added to the dental wax, the dental wax undergoes vigorous stirring at a speed ranging from 500 to 1000 rpm. This is carried out while the dental wax is still in its melting state. This is to ensure effective dispersion of the copolymer or the surface modified nano filler within the dental wax.

[0041] In a second aspect, a printable wax for use in printing 3D dental structure is provided. The printable wax comprises a dental wax, and a copolymer or a surface modified nano filler, wherein the printable wax has a viscosity of 0.1 to 200 Pa·s or 10 to 100 Pa·s.

[0042] The copolymer has a hydrophilic moiety and a hydrophobic moiety. In some embodiments, the copolymer is selected from the group consisting of poly(ethylene-co-vinyl acetate) (PEVA), poly(ethylene-co-methyl acrylate) (PEMA), poly(ethylene-co-acrylic acid), poly(vinyl alcohol-co-ethylene), or poly(ethylene-co-ethyl acrylate).

[0043] In the embodiment where the copolymer is poly(ethylene-co-vinyl acetate), the vinyl acetate content (wt%) ranges from 5 to 50 wt%, preferably from 20 to 40 wt%.

[0044] In the embodiment where the copolymer is poly(ethylene-co-methyl acrylate), the content of methyl acrylate ranges from 5 to 60 wt%, preferably from 15 to 30 wt%.

[0045] In the embodiment where the copolymer is poly(ethylene-co-acrylic acid), the content of acrylic acid ranges from 5 to 30 wt%, preferably from 5 to 20 wt%.

[0046] In the embodiment where the copolymer is poly(vinyl alcohol-co-ethylene), the content of vinyl alcohol ranges from 20 to 80 wt%, preferably from 30 to 50 wt%.

[0047] In the embodiment where the copolymer is poly(ethylene-co-ethyl acrylate), the content of ethyl acrylate ranges from 5 to 40 wt%, preferably from 10 to 20 wt%.

[0048] In some embodiments, the copolymer has a molecular weight ranging from 1000 to 20,000, or from 1000 to 10,000. In some embodiments, the copolymer is present in an amount ranging from 0.1 to 50 wt%, or 25 to 50 wt% based on the total amount of the dental wax.

[0049] In some embodiments, the surface modified nano filler is an inorganic surface modified nano filler selected from the group consisting of nano silica, nano titania, nano aluminium oxide and nano zinc oxide. In some embodiments, the surface modified nano filler is an organic surface modified nano filler selected from the group consisting of chitosan, cellulose, and carbon nanotube. In some embodiments, the surface modified nano filler has an

average particle size ranging from 2 to 500 nm, 2 to 100 nm, or 2 to 50 nm. In some embodiments, the surface modified nano filler is present in an amount ranging from 0.1 to 50 wt%, 0.1 to 33 wt% or 20 to 50 wt% based on the total amount of the dental wax.

[0050] Due to the dental wax being not tough enough to form into a filament, the dental wax cannot be printed using the common FDM technique that utilises filament. In the present disclosure, the inventors have adapted the printer by incorporating a syringe pump capable of heating the printable wax and a sensor to regulate the temperature. An exemplary embodiment of the syringe pump is illustrated in FIG. 2.

[0051] In a third aspect, a method of printing a 3D dental structure is provided. The method comprises introducing a printable wax of the present disclosure into a syringe pump; heating the printable wax in the syringe pump using a heating element that wraps around the syringe pump; controlling the temperature of the printable wax in the syringe pump; and commencing printing of a 3D dental structure when the temperature of the printable wax reaches its melting point.

[0052] In some embodiments, the printable wax in the syringe pump undergoes heating at a temperature ranging from 40 to 80 °C to achieve the required softening for 3D printing.

[0053] Referring to FIG. 2, the syringe pump 200 comprises a syringe body 202, a piston 204 disposed at a first end 205 of the syringe pump and an outlet 206 disposed at a second end 207 of the syringe pump, and a material 208 disposed between the syringe body 202 and the heating element 210 for conducting heat from the heating element 210 to the syringe body 202. The step of printing the 3D dental structure comprises activating the piston 204 to push the printable wax in the syringe body 202 towards the outlet 206 for dispensing the printable wax at a controlled speed for printing the 3D dental structure.

[0054] In some embodiments, the 3D dental structure includes, but is not limited to, dental bite registration, aligner, denture, dental crown, bridge, orthodontic model, surgical guide, mouthguard, dental splint, dental implant, and diagnostic model.

[0055] In some embodiments, the printing of the 3D dental structure takes about 15 to 30 min, 15 to 25 min or 15 to 20 min to complete.

[0056] The inventors of the present disclosure have devised a novel method to tune the complex viscosity of commercially available dental wax by adjusting internal frictional forces of the dental wax using copolymer or surface modified nano filler to make extrusion-based dental wax 3D printing possible. The method of the present disclosure allows dental wax to be softened at softening temperature within the range of 40 to 80°C. The resulting printable wax, obtained by the method of the present disclosure, allows for the 3D printing of dental structures within a relatively short period of time, ranging from 15 to 30 min, from 15 to 25 min or from 15 to 20 min. The method allows tuning of the viscosity of commercially available dental wax to suitable level for 3D printing of dental structures. The viscosity of the dental wax is modified to prevent dripping of the dental wax during 3D printing process, and the method offers a faster means of fabricating dental structures, such as dental bite registrations, in approximately 15 min.

[0057] To facilitate a better understanding of the present disclosure, the following examples of specific embodiments are given. In no way should the following examples be read to limit or define the entire scope of the disclosure. One skilled in the art will recognize that the examples set out below are not an exhaustive list of the embodiments of this disclosure.

EXAMPLES

Example 1

[0058] 3D Printing Using Commercial Dental Wax Directly

[0059] Commercial dental wax was filled into a customized metal syringe pump and then heated to melt in a water bath. The syringe pump was turned over to remove any gas bubble in the dental wax, and the dental wax was allowed to slow cool down to room temperature until all the dental wax solidified again. Then, the syringe pump was put into a heating mantle with a temperature control to warm up the dental wax until the dental wax became soft. Printing started after 30 min balance of the temperature. Because of the high fluidic of the melting wax, much wax dripped out during the printing, making all the printing failed. These results suggest that commercial dental wax are not suitable for 3D printing, primarily due to their extremely low viscosity in the melting state. Therefore, tuning the viscosity of the dental wax at the melting state is one of the most essential steps for successful 3D printing using dental wax.

Example 2

[0060] Surface Modification of Nano Silica with Silane

[0061] 2g of 5 nm size nano silica was dispersed in 100 ml mixture of ethanol and water with volume ratio of 75:25. Then, glacial acetic acid was added to the solution until the pH reached to around 4 to 5 under magnetic stirring. Then, 5 ml of 3-(2-aminoethylamino)propyltriethoxysilane was added slowly into the solution within 30 min. After a 4-hour reaction, the mixture was centrifuged at 12,000 rpm for 30 min, and washed with ethanol and water for 3 times. The precipitate was then dried in an oven at 80 °C for 6 hours.

Example 3

[0062] Printable Wax Preparation Using Nano Silica

[0063] Commercial dental wax was melted in a flask until all the wax were liquefied with low viscosity. Then, different amounts of surface modified silica prepared as described in Example 2 were added to the melted wax under vigorous stirring. When all the silica were well dispersed in the melted wax, heating stopped and the resulting wax was transferred to the syringe pump for 3D printing test. Part of the product was collected for complex viscosity test.

Example 4**[0064] Printable Wax Preparation Using Copolymer**

[0065] Commercial dental wax was melted in a flask until all the wax were liquefied with low viscosity. Then, different amounts of poly(ethylene-co-vinyl acetate) with vinyl acetate content of 25 wt% were added under vigorous stirring to the melted wax. When all the silica were well dispersed in the melted wax, heating stopped and the resulting wax was transferred to the syringe pump for 3D printing test. Part of the product was collected for complex viscosity test.

Example 5**[0066] Complex Viscosity Test**

[0067] For the viscosity test, a rheometer was used. The platform was heated to slightly above the melting temperature of each formulation, thereafter, a small piece of the sample, approximately 1 cm in diameter was loaded onto the platform. Temperature was ramped up from 50 to 120 °C $\pm$ 5 °C . From the results shown in FIG. 3A and FIG. 3B, we can see that the viscosity of the dental wax increases from 0.01 to 5 Pa·s when an amount of 0.1 to 50 wt% of copolymer is used (FIG. 3A), while the viscosity of the dental wax increases from increases from 0.01 to 110 Pa·s when an amount of 0.1 to 33 wt% of surface modified nano filler is used. The results show that significant complex viscosity increases for the modified dental wax, making it possible to print these waxes without dripping. The nano silica showed higher improvement in complex viscosity than the copolymer. This could be due to the high surface energy of the nano silica and strong filler–filler interaction.

Example 6**[0068] Printing Test**

[0069] The printable wax developed in Examples 3 and 4 were 3D printed using the customized 3D printer with the syringe pump, with temperature optimization and printing speed

optimization. FIG. 4 shows the successful 3D printing of the (A) denture bite box; and (B) ring model using the printable wax developed in Example 4 and Example 3, respectively. The results show that commercial dental wax with improved viscosity can be used for printing 3D dental structures as the printable wax does not drip out of the syringe pump during printing.

[0070] Although embodiments of the invention have been shown and described, the invention is not limited to the described embodiments. Instead, it would be appreciated by those skilled in the art that various modifications and variations can be made to the embodiments of the invention without departing from the scope of the invention, the scope of which is set forth in the following claims.

Claims

1. A method of preparing a printable wax with an improved viscosity for use in 3D printing in dentistry, the method comprising:
 - heating a dental wax to melt the dental wax;
 - adding a copolymer or a surface modified nano filler to the dental wax in an effective amount to tune the flow viscosity of the dental wax to a desired viscosity while the dental wax is still heated;
 - subjecting the dental wax to vigorous stirring to disperse the copolymer or the surface modified nano filler well in the dental wax; and
 - allowing the dental wax to cool down, resulting in a printable wax with improved viscosity for fast 3D printing.
2. The method of claim 1, wherein the copolymer has a hydrophilic moiety and a hydrophobic moiety.
3. The method of claim 2, wherein the copolymer has a molecular weight ranging from 1000 to 20,000.
4. The method of claim 2, wherein the copolymer is selected from the group consisting of poly(ethylene-co-vinyl acetate) (PEVA), poly(ethylene-co-methyl acrylate) (PEMA), poly(ethylene-co-acrylic acid), poly(vinyl alcohol-co-ethylene), and poly(ethylene-co-ethyl acrylate).
5. The method of claim 1, wherein the copolymer is added to the dental wax in an amount ranging from 0.1 to 50 wt% based on the total amount of the dental wax.

6. The method of claim 1, wherein the surface modified nano filler is an inorganic surface modified nano filler selected from the group consisting of nano silica, nano titania, nano aluminium oxide and nano zinc oxide.
7. The method of claim 1, wherein the surface modified nano filler is an organic surface modified nano filler selected from the group consisting of chitosan, cellulose, and carbon nanotube.
8. The method of claim 1, 6 or 7, wherein the surface modified nano filler has an average particle size ranging from 2 to 500 nm.
9. The method of claim 1, wherein the surface modified nano filler is added to the dental wax in an amount ranging from 0.1 to 50 wt% based on the total amount of the dental wax.
10. The method of claim 1, further comprising:
preparing the surface modified nano filler by modifying the surface of the nano filler with one or more functional silanes selected from the group consisting of acetoxylethyltrimethoxysilane, acetoxylethylmethyldichlorosilane, acetoxylethyltrimethoxysilane, acetoxymethyltriethoxysilane, N-(3-(Trimethoxysilyl)propyl)acrylamide, (2-Acryloxyethoxy)trimethylsilane, (3-acryloxypropyl)methyldichlorosilane, 3-[dimethoxy(methyl)silyl] propyl acrylate, 3-(trimethoxysilyl)propyl acrylate, 3-(2-aminoethylamino)propyltriethoxysilane, and (3-aminopropyl)triethoxysilane.

11. The method of claim 1, wherein the viscosity of the dental wax is tuned to 0.1 to 200 Pa·s.
12. The method of claim 1, wherein the copolymer or the surface modified nano filler is added to the dental wax when the dental wax is fully melted.
13. The method of claim 1, wherein the dental wax is selected from the group consisting of baseplate wax, bite registration wax, orthodontic wax, utility wax, sticky wax, and pattern wax.
14. The method of claim 1, wherein the dental wax is vigorously stirred at a speed ranging from 500 to 1000 rpm.
15. A printable wax for use in printing 3D dental structure comprising a dental wax; and a copolymer or a surface modified nano filler, wherein the printable wax has a viscosity of 0.1 to 200 Pa·s.
16. The printable wax of claim 15, wherein the copolymer has a hydrophilic moiety and a hydrophobic moiety.
17. The printable wax of claim 16, wherein the copolymer is selected from the group consisting of poly(ethylene-co-vinyl acetate) (PEVA), poly(ethylene-co-methyl acrylate) (PEMA), poly(ethylene-co-acrylic acid), poly(vinyl alcohol-co-ethylene), and poly(ethylene-co-ethyl acrylate).

18. The printable wax of claim 16, wherein the copolymer has a molecular weight ranging from 1000 to 20,000.
19. The printable wax of claim 15, wherein the copolymer is present in an amount ranging from 0.1 to 50 wt% based on the total amount of the dental wax.
20. The printable wax of claim 15, wherein the surface modified nano filler is an inorganic surface modified nano filler selected from the group consisting of nano silica, nano titania, nano aluminium oxide and nano zinc oxide.
21. The printable wax of claim 15, wherein the surface modified nano filler is an organic surface modified nano filler selected from the group consisting of chitosan, cellulose, and carbon nanotube.
22. The printable wax of claim 15, 20 or 21, wherein the surface modified nano filler has an average particle size ranging from 2 to 500 nm.
23. The printable wax of claim 15, wherein the surface modified nano filler is present in an amount ranging from 0.1 to 50 wt% based on the total amount of the dental wax.
24. A method of printing a 3D dental structure, the method comprising:
introducing a printable wax as defined in claim 15 into a syringe pump;
heating the printable wax in the syringe pump using a heating element that wraps around the syringe pump;
controlling the temperature of the printable wax in the syringe pump; and

commencing printing of a 3D dental structure when the temperature of the printable wax reaches the melting point.

25. The method of claim 24, wherein the syringe pump comprises a piston disposed at a first end of the syringe pump and an outlet disposed at a second end of the syringe pump, and a material disposed between the syringe pump and the heating element for conducting heat from the heating element to the syringe pump, and wherein the step of printing the 3D dental structure comprises:

activating the piston to push the printable wax in the syringe pump towards the outlet for dispensing the printable wax at a controlled speed for printing the 3D dental structure.

26. The method of claim 24 or 25, wherein the 3D dental structure is selected from the group consisting of dental bite registration, aligner, denture, dental crown, bridge, orthodontic model, surgical guide, mouthguard, dental splint, dental implant and diagnostic model.

27. The method of claim 24, wherein the printing of the 3D dental structure takes 15 to 30 minutes.