special update equipment
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IvoBase® – Innovative prosthetic system with low residual monomer content

With the IvoBase® system, users are provided with a fully automatic, shrinkage-compensating injection system, which not only supplies precision and an excellent bond to teeth, but also results in a defined residual monomer, or, more accurately, residual MMA content (according to ISO 20795-1:2008) in the denture base resins (MMA: methyl methacrylate). The user may choose between a residual MMA content of <1.5% with standard programs and <1.0% residual MMA with activation of the RMR function (RMR: residual monomer reduction). This is enabled by the microprocessor-controlled regulation technology and it also covers a wealth of different material types.

Subject: IvoBase – Innovative prosthetic system with low residual monomer content

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MMA/PMMA-based denture base resins

A staggering 90% of the denture base materials used throughout the world are PMMAs (polymethyl methacrylates) (11). The outstanding clinical and processing-related properties as well as the inexpensive availability have allowed the success of this material class to last for now more than 75 years (1, 2, 3, 13). Other material classes, such as composites or UDMA derivatives (UDMA: urethane dimethacrylate) with different polymerization mechanisms (light-curing, microwave-curing, etc.) have been unable to establish themselves on a wide scale in removable denture prosthetics because of recurring problems, such as brittleness, susceptibility to plaque, time-consuming processing and not least the higher price. A true alternative material to PMMA is currently not available.

Figure 1: Analysis samples in the gas-phase chromatograph

„Refinement" of PMMA

A resin denture never consists of pure MMA/PMMA. Rather, it contains a multitude of additives and auxiliary materials, such as pigments for colouring. In order to achieve the cross-linking of the polymer matrix, a dimethacrylate, e.g. 4-8% ethylene or butylene glycol dimethacrylate, is added to the liquid component. This results in improved chemical resistance and also enhances the physical properties, such as the modulus of elasticity and flexural strength. PMMA copolymers are used in the powder phase to influence the processing properties of the denture base system. As initiator system in heat-curing polymers, dibenzoyl peroxide (BPO) as a radical former has been established for decades. For modern, auto-curing PMMA denture resins that demonstrate stability of shade, BPO/barbituric acid derivatives are used nowadays as redox system (2, 4, 5, 13).

What is the meaning of residual monomer?

Reactive, low-molecular molecules are called monomers. In the case of denture base resins, it mainly means methyl methacrylate (MMA), which can be radically polymerized by means of auto-polymerization or heat polymerization. In all powder-liquid systems for denture base materials, MMA is the reactive main component of the liquid phase. A chemical reaction such as the radical polymerization from MMA to PMMA never covers 100% (8). This means that low quantities of unpolymerized MMA are present in all materials containing PMMA. This is also true for industrially polymerized PMMA or composites with PMMA fillers, among them even many so-called hypo-allergenic denture base resins (6).

A multitude of different monomers are used in dental materials (UDMA: urethane dimethacrylate, TEGDMA: tetraethylene glycol dimethacrylate, EGDMA: ethylene glycol dimethacrylate, and many more), which are also still present in the completed object as residual monomer. In the discussions about the biocompatibillity of dental materials, however, this fact is often ignored, even though residual monomer may also have a sensitizing, i.e. allergy-causing, effect by absorption through the skin (7).

Toxicology of MMA

MMA is a volatile substance with excellent solvent properties, which is irritating to skin and mucous membrane and can be easily absorbed by the body. Moreover, MMA is irritating to the respiratory system. However, it only has a harmful effect in very high doses, which are not reached during standard processing or which are prevented by the strong odour (8). The highest risk is thus present for the processors, i.e. dental technicians. Skin contact with unpolymerized material has to be prevented and suction equipment must be used during processing. Commercial medical gloves do not provide protection against MMA. The Ivocap and IvoBase materials are supplied in predosed capsules, which virtually eliminates skin contact and thus protects dental technicians.

According to today's literature, whether residual MMA really does have an allergenic potential in mucous membrane-borne dentures is rather questionable. Nevertheless, to keep the risk to patients to a minimum, modern denture systems must be designed in such a way that the residual MMA content in the denture body is as low as possible. In contrast, polymerized MMA, PMMA, is toxicologically completely safe and, besides, demonstrates outstanding clinical properties, such as limited susceptibility to plaque accumulation or colonization of micro-organisms, as well as chemical resistance and a low tendency for discolouration.
For that reason, PMMA is often used as a comparison in plaque studies on dental materials.

What does the EN ISO 20795-1:2008 standard say?

The monomer conversion in radical polymerization is strongly influenced by external factors. Both the reaction temperature and surface conditions (oxygen inhibition) or geometric factors, such as the thickness of the denture body, decisively influence the residual monomer content. It is therefore absolutely normal that the residual monomer content varies within dentures. For that reason, the currently valid standard for denture base resins (EN ISO 20795-1:2008) works with standard specimens (circular shape with a diameter of 50 mm and a height of 3 mm).

In injection methods, such as Ivocap or IvoBase, the steel moulds described in the standard under 8.8.2.1.1 cannot be used, since the heat conductivity of the steel does not allow shrinkage compensation. Moreover, they are generally unsuitable for injection. Therefore, circular silicone specimens with the required dimensions must be fabricated using these steel moulds and directly invested in the IvoBase and Ivocap flasks. According to 8.8.2.1.2 of the same standard, this deviation from the procedure is permitted for encapsulated materials.

Figure 2: Investment of the silicone moulds to determine the residual monomer content.

Figure 3: Left: polymerized ingot; right: ground ingot

Polymerization is performed according to the Instructions for Use. After divesting, the test specimens have to be stored according to the defined storage conditions and times and then ground to a thickness of 2.0 ± 0.1 mm on both sides with a grinding machine using metallographical sandpaper. After grinding and renewed storage, the test specimens are crushed and the MMA is extracted from the denture base resin with the help of acetone. After 72 hours of stirring at room temperature, the content of the extracted MMA is analytically determined either by means of gas-phase chromatography (GC) or High Performance Liquid Chromatography (HPLC) and back-calculated to the initial weight. The values obtained in such a way correspond with the average value of the entire round test specimen.

Figure 4: Crushing the test specimen to determine the initial weight

Figure 5: Extraction of the methyl methacrylate by stirring in acetone for 72 hours

Figure 6: Loading the gas-phase chromatograph

How can the residual monomer content be influenced?

It is commonly known that a reduction of the residual monomer content can be achieved by prolonging the polymerization time during the production of denture base resins (9, 10). For this purpose, temperatures of above 80 °C/176 °F are particularly effective. These conditions usually occur during the processing of heat-curing polymers.
Therefore, the residual MMA content stipulated in the standard is clearly lower (<2.2%) than that of auto-curing polymers (<4.5%) with typical polymerization temperatures of <60 °C/<140 °F. For optimally polymerized heat-curing PMMA for denture base resins, stable residual MMA contents of 0.5% can be achieved. A value below 1% is already considered a very thoroughly polymerized system.

If the initial residual monomer content of conventional auto-curing polymers is to be reduced to below 1%, thermal post-processing at a temperature of >80 °C/>176 °F is required. However, the dentures have to be invested in stone for that purpose, since the thermal treatment may result in tensions being loosened, which may cause deformation of the dentures. Since this process step is simply added to the regular processing time with IvoBase, no additional efforts are required.

Figure 7: Easy activation of the RMR function before the start of the program

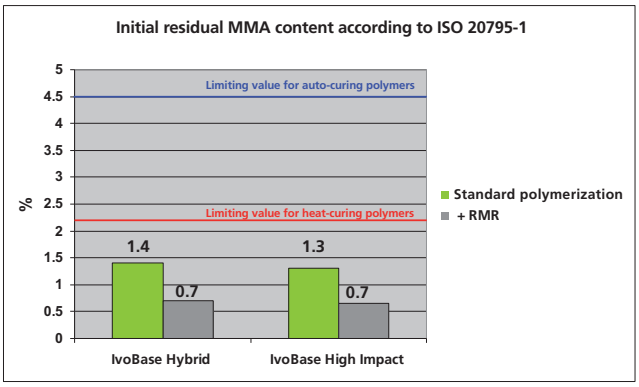

Table 1: Initial residual monomer content of IvoBase denture base resins (Ivoclar Vivadent AG)

The meaning of RMR in the IvoBase system

Despite being auto-curing polymers in chemical terms, IvoBase denture base resins achieve initial residual MMA contents that are below the required value for heat-curing polymers and that are comparable to them in tests conducted in accordance with the standard (Table 1).

In standard procedures, reproducible values of <1.5% are achieved. With the additional activation of the RMR function, this value can be lowered to <1.0% by prolonging the polymerization time (approximately 10–15 minutes). Typically, the residual monomer contents for IvoBase Hybrid and High Impact are at 0.7%. This is an exceptionally low initial value for an auto-curing polymer. Conventional auto-curing polymers do not reach such initial values. Consequently, the potential risk for patients can be reduced to a very low level with the IvoBase system.

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