

The evolution and advancement of

Dental Thermoplastics

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Thermoplastic materials for dental prostheses, Valplast and Flexiplast, were first introduced to dentistry in the 1950s. Both materials were similar grades of Polyamides (nylon plastics). Since their introduction, there has been a continued interest in thermoplastic dental materials.¹

Development History

Rapid Injection Systems (currently known as The Flexite Company), originated in 1962. The company introduced the first Flexite thermoplastic which was a flouropolymer (a Teflon-type of plastic).

Valplast introduced a flexible semi-translucent thermoplastic resin to create flexible tissue-born partial dentures. While the material was not strong enough to allow for conventional tooth born rest seat, the flexibility added to patient comfort in wearing the appliances.

Flexite also was early into the dental market with flexible thermoplastic acrylic hybrid resin for removable appliances. Acetal was first proposed as an unbreakable thermoplastic resin removable partial denture material in 1971². It was during this period that Rapid Injection Systems developed the first tooth-colored clasps with a flouropolymer thermoplastic.

In 1986, Dental 'D' reintroduced tooth-colored clasps using Acetal resin. The clasps were flexible, didn't need periodic adjusting to keep them tight, and the tooth colored esthetics were appreciated by the patients. Pressing Dental followed in the early 1990s with an acetal resin, (marketed in the U.S. by DENTSPLY Austenal), which in addition to tooth colored clasps, has been used for an entire partial denture framework as well as other appliances.

In 1992, The Flexite Company, developed and patented the first pre-formed tooth-color clasps known as Clasp-Eze. This product, made of a nylon material, is available in pink and clear color shades and currently sold worldwide.



Fig 1: Aesthetic Perfection Acetal resin materials and samples from Cosmetic Dental Materials, Inc.

DENTSPLY recently introduced the Success FRS, "flexible resin system" for their Success denture press. The FRS system utilizes a flexible tissue colored thermoplastic resin for flexible partial dentures. Currently Cosmetic Dental Materials, has introduced Aesthetic Perfection™ (patent pending), a new line of thermoplastic Acetal, Acrylic, and Polycarbonate materials that can be used in most thermoplastic presses, Fig. 1. These materials offer excellent esthetics combined with favorable physical properties and easy processing characteristics.

Advantages of thermoplastic materials

Thermoplastic resins and co-polymers have many advantages over conventional powder or liquid resin systems. Thermoplastic resins tend to have predictable long-term performance. They are stable and resist thermal polymer unzipping. They also exhibit high creep resistance and high fatigue endurance as well as excellent wear characteristics and solvent resistance. Thermoplastic resins typically have very little or almost no free monomer in the material. A significant percentage of the population is allergic to

free monomer and these materials offer a new safe treatment alternative for these individuals. In addition, thermoplastic materials have almost no porosity, which reduces biologic material build up, odors, and stains and they also exhibit higher dimension and color stability. All of these factors become important when producing long-term provisional prostheses during implant or complex restorative cases, or when used for permanent removable appliances. Typically the thermoplastic resins are more flexible and stronger than their traditional counterparts. Elastomeric resins can be added to the resin polymer formulas to create greater flexibility, which reduces fracturing. Thermoplastic resins can also be reinforced with glass filler or fibers to further enhance their physical properties^{3,4}. At the same time, these restorations can be relined and repaired, by repressing the restoration. The thermoplastic resins can produce single cast or pressed restorations that are strong, lightweight, flexible appliances in tissue or tooth color matched materials that never need adjusting. These restorations display excellent esthetics and provide long-term comfortable use for the patient. This provides excellent alternative cosmetic restorations for esthetic-conscious patients. Thermoplastic resins have and are being used for a broad variety of applications from removable flexible partial dentures, preformed partial denture clasps, fiber reinforced fixed partial dentures⁵, temporary crowns and bridges, provisional crowns and bridges, obturators and speech therapy appliances, orthodontic retainers and brackets, impression tray⁶ and border molding⁷ materials, occlusal splints, sleep apnea appliances, and implant abutments.

Thermoplastic Acetal

Acetal as a homo-polymer has good short-term mechanical properties, but as a co-polymer, acetal has better long-term stability. Acetal resin is very strong, resists

Continued on page 54

Dental Thermoplastics

Continued from page 52

wear and fracturing, and is quite flexible. These characteristics make it an ideal material for pre-formed clasps for partial dentures, single pressed unilateral partial dentures, partial denture frameworks, provisional bridges, occlusal splints, and even implant abutments. Acetal resins resist occlusal wear and are well suited for maintaining vertical dimension during provisional restorative therapy.

While stronger, acetal does not have the natural translucency and vitality of thermoplastic acrylic and polycarbonate, and these materials might offer better results for short term temporary restorations.

Thermoplastic Polycarbonate

Polycarbonate is a polymer chain of bisphenol-A carbonate. It is a popular material and has been used in dentistry for a long time as preformed temporary crown shells. Like acetal resin, polycarbonate resin is also very strong, resists fracturing, and is quite flexible. However, polycarbonate does not wear as well as acetal during occlusal force and consequently will not maintain vertical dimension as long. Polycarbonate is ideally suited for provisional crowns and bridges but not suitable for partial denture frameworks. The material has a natural translucency and finishes very well, yielding excellent esthetics. Temporary and provisional restorations with thermoplastic polycarbonate provide patients with excellent short or mid-term function and esthetics.

Thermoplastic Acrylic

Acrylic is better known as polymethyl methacrylate or PMMA. This material has been used in dentistry for many years in the form of temporary crowns and thermal polymerized as baseplate material for partial and complete dentures. Thermal polymerized PMMA demonstrates high porosity, high water absorption, volumetric changes and residual monomer⁸. These properties lead to many of the problems associated with thermally polymerized acrylic versus the thermoplastic version. Thermoplastic acrylic has poor impact resistance, but has adequate tensile and flexural strength for a variety of applications. The material is easy to adjust, handle and polish. It is relinable and repairable chairside. Thermoplastic acrylic is available in both tooth and gin-



Fig 2 (left): Unilateral single cast, single tooth replacement acetal partial denture.

Fig 3 (below): Acetal resin mandibular partial denture framework with acrylic saddles and denture teeth processed to the framework.



gival colors, and has both translucency and vitality, providing excellent esthetics. Like most thermoplastic resins, acrylic resin is also strong, resists fracturing, and is flexible. However, acrylic does not wear as well as acetal during occlusal forces and consequently will not maintain vertical dimension over long periods of time.

Flexite M.P.—a thermoplastic acrylic, is a special blend of polymers and has the highest impact rating of any acrylic. You can bounce a Flexite M.P. denture off the floor without cracking the base. Flexite M.P. has a surface hardness of 55-65, making it popular for bruxism appliances as well as dentures.

Thermoplastic Nylon

Nylon is a resin derived from diamine and dibasic acid monomers. From an engineering standpoint, nylon is a versatile material with a depth of characteristics making it suitable for a broad range of applications. Nylon exhibits high physical strength, heat resistance and chemical resistance. It can easily be modified to increase stiffness and wear resistance. Because of its excellent balance of strength, ductility and heat resistance, nylon is an outstanding candidate for metal replacement applications. However, in dentistry, because of its inherent flexibility, it is used primarily for flexible tissue born partial dentures. It does not have enough strength to use for occlusal rest seats, and won't maintain vertical dimension when used in direct occlusal forces. Thermoplastic nylon is injected at temperatures from 274 to 293 C and has a specific gravity of 1.14. Mold shrinkage amounts to 0.014 in/in. The tensile strength is 11000 psi and the flexural

strength is 16000 psi. Nylon is a little more difficult to adjust and polish, but the resin can be semi-translucent and provides excellent esthetics for flexible tissue born partial dentures.

Applications for Thermoplastic Resins

Applications for thermoplastics resins originally involved flexible tooth born partial dentures. Currently dental applications include: preformed partial denture clasp, flexible tooth born partial denture framework, single cast partial dentures, temporary crowns and bridges, provisional crowns and bridges, occlusal appliances, implant abutments, orthodontic and sleep apnea appliances, many of which have been described previously. However, with the development of new elastomers and copolymer alloys, there are certain to be many new clinical applications for thermoplastic resins in dentistry.

Clinical Examples

The first clinical example is a single cast partial denture. The unilateral appliance is injected in one process with acetal resin, tooth color matched by standard Vita shades, Fig 2. The clasp, rest seats and pontic are all injected as a uniform piece of acetal resin. The clasps provide excellent retention, are esthetic and the restoration supplies proper occlusal function and maintains vertical dimension.

Acetal resin is also ideally suited to

Continued on page 56

Dental Thermoplastics

Continued from page 54

replace chromium in the fabrication of a tooth born partial denture. In this example, the lingual apron major connector and clasps and framework are all pressed as a single and continuous piece of acetal resin. Then the partial denture is completed by traditional methods, with denture teeth and acrylic baseplate resin, Fig 3. In the mouth, the partial denture is functional, esthetic, and the flexibility and light-



Fig 4: Clinical photo of the acetal mandibular partial denture.



Fig 5: Traditional metal cast unilateral partial denture, clinical photo.

weight make the restoration very comfortable to wear, Fig 4. Patients really appreciate the tooth colored esthetics.

Acetal resin can be used for a variety of applications in restorative appliances. The inert, bio-compatible properties, strength and esthetics make it suitable for provisional bridges, occlusal splints, partial dentures and a number of additional restorations. The esthetics and comfort are two advantages most appreciated by patients. A traditional unilateral partial denture with cast metal framework is rigid, uncomfortable and unesthetic, Fig 5. An acetal single cast partial denture that is color matched for the patient is both esthetic and the flexibility aids in retention and comfort, Fig 6. While the

acetal resin clasps virtually never need adjustment, they can be adjusted with a heated set of 3-prong pliers.

Conclusion

Thermoplastic resins have been used in dentistry for over 50 years. During that time the applications have continued to grow, and the interest in these materials by both the profession and the public have increased. The materials have superior properties and characteristics and provide excellent esthetic and biocompatible treatment options. With the development of new properties, elastomers and copolymer alloys, there are certain to be additional new applications for thermoplastic resins in the future⁹, to help patients with damaged or missing teeth.



Fig 6: Acetal resin unilateral single cast partial denture, clinical photo after.



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