

Contact Angles of Contemporary Type 3 Impression Materials

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The aim of this study was to investigate the contact angles of six different type 3 dental impression materials (DIMs). Contact angles ($n = 3$) were continuously determined for 20 seconds after placing 4 μL of deionized water onto a thin layer (50 μm) of freshly mixed DIM (polyvinyl siloxane, C-silicone, polyether, and hybrid DIMs). Data were subjected to parametric statistics ($P < .05$). Contact angles ranged from 76.1 ± 5.6 degrees to 119.5 ± 1.8 degrees at 0 seconds and from 11.7 ± 1.6 degrees to 74.7 ± 1.1 degrees at 5 seconds after droplet deposition. The siloxanes showed significantly higher contact angles at 0 and 5 seconds compared to all other DIMs tested ($P < .05$). The newly introduced DIMs with a polyether backbone showed promising results regarding their hydrophilicity. *Int J Prosthodont* 2009;22:396–398.

A major challenge for a dental impression material (DIM) is to wet the prepared tooth structure as well as possible to obtain a precise impression.¹ Although there is no clear evidence as to which inherent properties might specifically affect a material's wetting ability,² hydrophilicity is regarded as a major influencing factor.³ Recently, a couple of new DIMs with modified chemistries were introduced to the dental market. However, current literature is lacking scientific data about their hydrophilicity.

Therefore, the aim of this study was to test the following null hypothesis: The chemical structure of an impression material does not influence the contact angles, determined immediately after mixing.

Materials and Methods

Six type 3 viscosity (according to ISO 4823⁴) DIMs were investigated at ambient laboratory conditions ($23^\circ\text{C} \pm 1^\circ\text{C}$, $50\% \pm 5\%$ relative humidity) (Table 1).

The polyvinyl siloxane (PVS) Flexitime (Heraeus Kulzer) as well as the PVS/polyether blend Fusion (GC Dental) and the experimental DIM Identium (IDENT-EXP, Kettenbach) cured by a Pt-catalyzed hydrolyzation reaction of vinyl end groups (Bublewitz A, personal communication, 2008). P2 (Heraeus Kulzer) reportedly cures via an acid catalyzed cross-linking reaction of end groups of a silane-terminated polyether compound (Grundler A, personal communication, 2006). Xantopren is a classic C-silicone that cures by a condensation reaction.

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Table 1 Impression Materials Under Investigation

Material*	Manufacturer	Code	Lot	Type
Flexitime Correct Flow	Heraeus Kulzer	FLEX	210473	Polyvinyl siloxane (PVS)
Fusion Light Body	GC Dental Products	FUS	0412271	Hybrid polyether/PVS
Identium Light Body (experimental)	Kettenbach	IDENT-EXP	07707-712	Hybrid polyether/PVS
Impregum Garant L DuoSoft	3M ESPE	IMP	B: 202183 C: 201970	Polyether
P2 Polyether Light	Heraeus Kulzer	P2	230213	Polyether
Xantopren Comfort Light	Heraeus Kulzer	XANT	270404	C-Silicone

*All materials were type 3 viscosities according to ISO 4823.

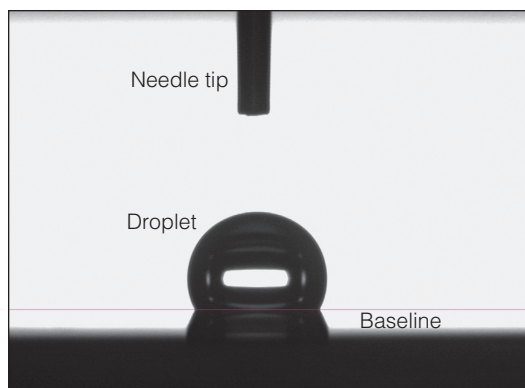


Fig 1 Exemplary photograph of a droplet (4 μ L) immediately after deposition on the freshly mixed impression material (PVS). Baseline marked in red. Note the clear borders between the droplet and background.

Hydrophilicity was evaluated by contact angle measurement (DSA10). Freshly mixed DIM was dispensed into a 50- μ m-deep notch of a stainless steel block. A thin layer was formed using a glass slide covered with a teflon foil ($n = 3$ for all DIMs, except for IDENT-EXP $n = 12$). Exactly 30 seconds after the start of mixing, a droplet (4 μ L) of deionized water was carefully placed onto the surface of the DIM from a needle tip. Contact angles were determined continuously for 20 seconds (12.5 fps) after droplet deposition (Fig 1).

A one-way analysis of variance (ANOVA) followed by the Tukey test was applied for statistical analysis ($P < .05$) and to identify significant differences between the materials tested at 0, 1, and 5 seconds after droplet deposition.

Results

Figure 2 depicts the contact angles determined. All materials showed high contact angles at $t = 0$ seconds (> 70 degrees) and a steep decline of the curve at the beginning.

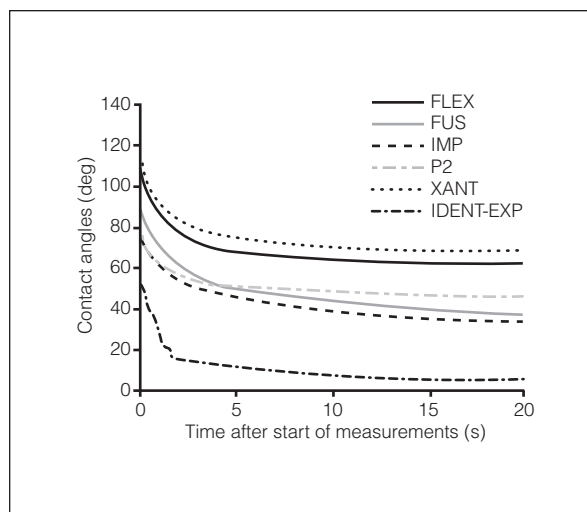


Fig 2 Time dependent contact angles of the impression materials tested. The point in time $t = 0$ of droplet deposition represents 30 seconds after mixing.

The one-way ANOVA revealed a highly significant influence of the DIM used ($P < .001$). Table 2 shows the mean contact angles at the three points in time after droplet deposition. The siloxanes showed significantly higher contact angles compared to all other materials at 0 and 5 seconds ($P < .05$). A high standard deviation was noticeable for IDENT-EXP.

Discussion

The hydrophilicity of a DIM is regarded as a major influencing factor for wetting the prepared tooth surface and in turn, the precision of the impression obtained.³ Hence, the aim of this study was to determine the contact angles of different DIMs immediately after mixing, which is widely considered an appropriate means of measure to assess the hydrophilicity of an impression material.^{3,5}

Since the hydrophilicity up to the first seconds after application of a DIM is regarded as essential to create an accurate impression,³ mean values for the contact angles were calculated at 0, 1, and 5 seconds.

Table 2 Mean Values and Standard Deviations for Contact Angles Determined 0, 1, and 5 Seconds After Droplet Deposition*

Material	n	0 s (deg)	1 s (deg)	5 s (deg)
FLEX	3	116.1 ± 2.0 ^c	87.7 ± 0.5 ^b	68.0 ± 0.3 ^d
FUS	3	95.6 ± 2.0 ^b	70.6 ± 0.4 ^{a,b}	49.8 ± 1.6 ^c
IDENT-EXP	12	97.7 ± 8.2 ^b	35.5 ± 22.0 ^a	11.7 ± 1.6 ^a
IMP	3	76.1 ± 5.6 ^a	61.9 ± 2.8 ^{a,b}	45.6 ± 1.4 ^b
P2	3	84.6 ± 10.3 ^{a,b}	62.4 ± 0.8 ^{a,b}	51.3 ± 0.1 ^c
XANT	3	119.5 ± 1.8 ^c	92.1 ± 1.8 ^b	74.7 ± 1.1 ^e

*Same superscript letters denote material groups that are significantly different (Tukey test $P < .05$).

The experimental material IDENT-EXP showed a broad scattering of values within the first 1.5 seconds, whereas all other materials showed small standard deviations. Hence, the number of specimens was increased to 12 for this DIM.

The high contact angles determined for the PVS and C-silicone can be related to their apolar backbone chemistry (Si-O chains with alkyl side groups).^{1,6} Although manufacturers add surfactants to these materials, the hydrophilicity of the siloxanes is still lower compared to a conventional polyether.^{1,5}

In contrast, the polyether backbone contains polar groups (eg, carbonyl and ether groups), which makes these DIMs more hydrophilic.⁶ The backbone of the newly introduced hybrid DIMs reportedly comprise functional groups of a polar nature similar to a polyether (Bublewitz A, personal communication, 2008), which seem to have a positive impact on their hydrophilicity.

It was noticed that the contact angles of the experimental material IDENT-EXP were lower at 1 second when compared to the conventional polyether, which is regarded the gold standard with respect to hydrophilicity.³ These results might be related to the modified polyether backbone chemistry, and probably to the surfactants added to this material. The results suggest that the new hybrid DIMs with polyether backbones have improved hydrophilic properties compared to traditional PVS materials and C-silicones.

Conclusions

The null hypothesis was rejected, as the contact angles of the freshly mixed DIMs were material dependent.

The newly introduced hybrid DIMs with polyether backbone chemistry showed promising results regarding their hydrophilicity. Further studies are required to verify if these results are reflected by a better wetting of the prepared tooth structure under wet conditions and in turn, the clinical outcome of the final restoration.

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References

1. Shen C. Impression materials. In: Anusavice KJ (ed). *Phillips' Science of Dental Materials*. St. Louis: Saunders, 2003:205-254.
2. Boening KW, Walter MH, Schuette U. Clinical significance of surface activation of silicone impression materials. *J Dent* 1998; 26:447-452.
3. Kugel G, Klettke T, Goldberg JA, Benchimol J, Perry RD, Sharma S. Investigation of a new approach to measuring contact angles for hydrophilic impression materials. *J Prosthodont* 2007;16:84-92.
4. *Dentistry—Elastomeric impression materials*, ed 3. ISO 4823. International Standardization Organization, 2000.
5. Mondon M, Ziegler C. Changes in water contact angles during the first phase of setting of dental impression materials. *Int J Prosthodont* 2003;16:49-53.
6. Rupp F, Axmann D, Jacobi A, Groten M, Geis-Gerstorfer J. Hydrophilicity of elastomeric non-aqueous impression materials during setting. *Dent Mater* 2005;21:94-102.