ORIGINAL ARTICLE

SETTING CHARACTERISTICS OF THREE COMMERCIAL VINYL POLYSILOXANE IMPRESSION MATERIALS MEASURED BY AN OSCILLATING RHEOMETER

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ABSTRACT

The aim of this study was to determine the setting characteristics of three commercial vinyl polysiloxane (VPS) impression materials at two different temperatures (23°C and 37°C). The objects were to investigate the effect of temperature and to compare the setting profile of these materials with each other using an oscillating rheometer. The three commercial VPS used were Aquasil Ultra Monophase (Aq M), Elite HD Monophase (Elt M) and Extrude Medium bodied (Extr M). For each material (n=5), 2 g VPS was extruded on to the lower plate of the rheometer and then the upper plate was positioned on top. The temperature was controlled using a thermostatically controlled water bath. Working time was calculated as 95% of the full trace recorded and setting time when the trace became parallel. Increasing the temperature significantly decreased the working and setting time for all materials tested. At 23°C there was no significant difference between the working time of Aq M and Extr M, which were significantly longer than Elt M. Extr M had the highest mean working time at 23°C and Elt M had the lowest mean working time. At 37°C the working time for Elt M was significantly shorter than Extr M and there was no significant difference with Aq M. The setting and working time for Elt M at 23°C and 37°C were significantly shorter compared with Aq M and Extr M. Aq M and Extr M at 23°C showed no significant differences. The working and setting time of all the materials were temperature dependent.

Key Words: *Impression material; elastomers; vinyl polysiloxane; working and setting time.*

INTRODUCTION

Among all elastomeric impression materials, the Vinyl polysiloxane (VPS) impression materials are widely used because of their greater elastic recovery, superior accuracy and better dimensional stability.[1-4] These materials are used to record impressions where reproduction of fine details is needed, such as in the construction of crowns and bridges.[5,6] The VPS impression materials were first introduced in 1970's and since then these materials are most commonly used for recording impressions.[4,7-9] The VPS impression materials are supplied as a two pastes system. The base paste contains poly (methylhydrosiloxane) as well as poly (dimethylsiloxane) prepolymer with vinyl terminal groups. The poly (methylhydrosiloxane) is a moderately low molecular weight prepolymer in which some of the methyl groups are replaced by pendant or terminal hydrosilane groups. The catalyst paste contains vinyl-terminated poly (dimethylsiloxane) and a catalyst such as chloroplatinic acid.[8,10-12] The fillers, such as amorphous silica or fluorocarbons, are added to both the pastes to improve mechanical properties.[7,10] The VPS impression materials are presented in different viscosities; extra light-bodied, light-bodied, medium-bodied, heavy-bodied and putty.[8,10,13] When the two pastes are mixed, an addition polymerisation reaction occurs forming a cross-linked molecules in the set state.[7,12,14,15]

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Working time of elastomeric impression material is the period from the start of mixing of the two pastes to the commencement of elasticity and loss of plasticity, where further manipulations will introduce distortion.[16] Ideally working time should exceed the time required for mixing, filling the tray, injecting the material on the prepared tooth/teeth, and seating the tray in the mouth.[17] Setting time of elastomeric impression material is the time between the start of mixing until the polymerisation process has advanced sufficiently and developed elastic properties that permit the removal of the impression from the mouth over undercuts.[8,18]. Usually there is a correlation between the working and setting time; longer the working time, longer will be the setting time and vice versa.[18] Ideally an impression material should have a rapid setting time provided the material has enough working time.[17]

Working and setting time of elastomeric impression materials increases with a decrease in temperature.[15,19] To extend their working time two methods have been employed. Some manufacturers incorporate a retarder into their compositions (e.g. oleic or stearic acid) without compromising other properties. But the widely used method is to refrigerate impression pastes, which can extend the working time by approximately 1.5 minutes, without affecting the material's accuracy.[7,20,21] Bonsor and Pearson[15] reported the working and setting time of elastomeric impression materials at two different temperatures (23ºC and 37ºC), to simulate the ambient temperature of the dental surgery and patient's mouth respectively. Their data showed that the impression materials tested had faster working and setting time at the elevated temperature. They also demonstrated that polysulphide impression materials had much longer working time (4 to 6 minutes) and setting time (12 to 16 minutes) at 23ºC and 37ºC respectively, compared to vinyl polysiloxane (VPS), condensation silicone and polyether impression materials.

The amount of filler content also affects the working and setting time; with an increase in filler content there is a decrease in working and setting time.[8] The manufacturers supply elastomeric impression materials with two different setting time (regular setting and fast setting) to save time for dental staff and for the comfort of the patient.[22]

The importance of impression materials and their optimum use cannot be under mined. Special emphasis should be paid to the setting characteristics of these materials in order to make the best use in clinical settings. The working and setting time vary according to the manufacturer. This study attempts to measure these timings and corresponding temperatures accurately. The purpose of this study was to evaluate the setting characteristics of three medium bodied VPS impression materials at two different temperatures (23ºC and 37ºC) to simulate the ambient temperature of the dental surgery and patient's mouth respectively.

METHODOLOGY

I. Materials

The commercial VPS impression materials used in this study were hydrophilic according to the literature provided by the manufacturers (Table 1). These materials were supplied through auto-mixed cartridge delivery system.

II. Procedure

The working and setting time of commercial VPS (n=5) were determined at two different temperatures (23ºC and 37ºC). An oscillating rheometer (Fig 1), attached to a chart recorder[17], was used to monitor the setting characteristics (Fig 1b). The equipment was calibrated each time before use. For each material (n=5), 2 g VPS was extruded directly on to the centre of the surface of the lower plate (diameter = 25 mm) of the rheometer and then the upper plate (diameter = 25 mm) was placed on top and fixed in position. The components of each VPS were weighed on a four figure balance, Mettler, Toledo Ltd, Model AG204, UK. The gap between the two plates was 2 mm. The oscillation was commenced when the material entered into the mixing nozzle of the auto-mixing syringe. The rheometer output produced a continuous trace over time on the chart recorder, which was set at a speed of 5 mm min-1. The amplitude of the trace decreased with an increase in viscosity, as the setting proceeded. The recording was continued until the amplitude of the trace reached a constant width. The temperature (23ºC and 37ºC) was controlled using a thermostatically controlled water bath, which circulated water through the upper plate (Fig 1 c, d). Working time was calculated as 95% of the full trace recorded and setting time was calculated when the trace became parallel (Fig 1e).[23,24]

III. Statistical analysis

The results were analysed by one way ANOVA and Tukey's Honest Significant Difference (HSD) test using the SPSS PASW statistical[22] software. One-way ANOVA was used to analyse the significant differences between the means of the groups. If the differences were

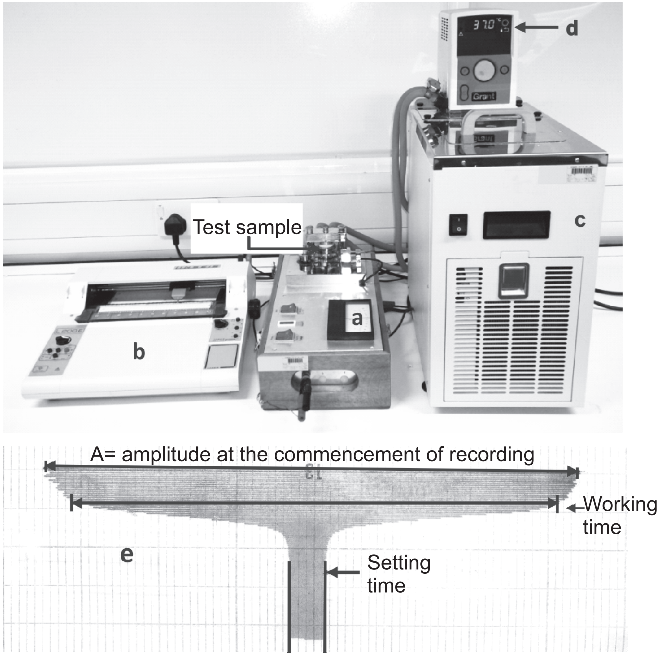

Fig 1: (a) Oscillating rheometer, (b) chart recorder connected to rheometer, (c) water bath, (d) thermostat, (e) A typical trace demonstrating the working time and setting time points at 37ºC ± 1ºC for a VPS impression material (n=5).

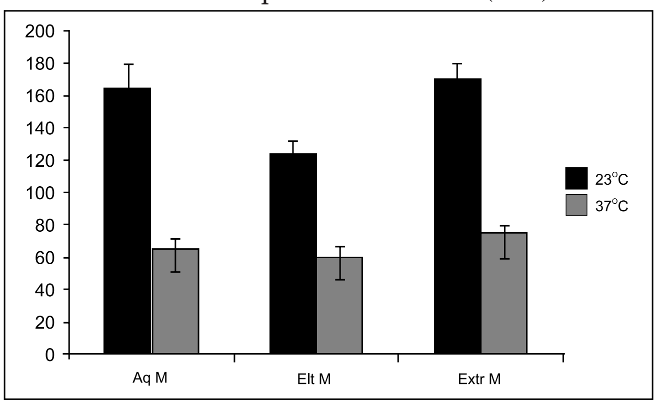

Fig 1: Mean (± standard errors; n=5) working time (seconds) for commercial VPS (Aq M, Extr M and Elt M) at 23ºC and 37ºC

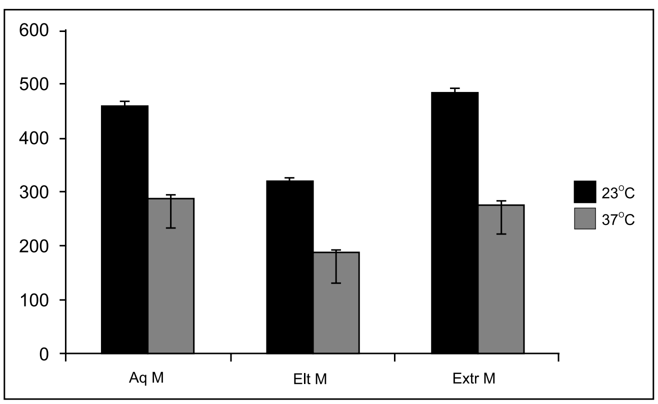

Fig 2: Mean (± standard errors; n=5) setting time (seconds) for commercial VPS (Aq M, Extr M and Elt M) at 23ºC and 37ºC

TABLE 1: COMMERCIAL VPS IMPRESSION MATERIALS (REGULAR SET) USED IN THIS STUDY

Commercial VPS	Lot/batch number	Manufacturers
Aquasil Ultra Monophase (Medium-Bodied), (Aq M)	090505	Dentsply, USA
Elite HD Monophase (Medium-Bodied), (Elt M)	95503	Zhermack, Italy
Extrude (Medium-Bodied), (Extr M)	0-1068	Kerr, USA

TABLE 2: MEAN (N=5) WORKING AND SETTING TIME OF THREE COMMERCIAL VPS IMPRESSION MATERIALS

Temperature	Working time (seconds)			Setting time (seconds)		
	Aq M	Elt M	Extr M	Aq M	Elt M	Extr M
	164	124	170	460	320	482
	65	60	74	288	190	277

significant between the groups, further analyses were carried out with post hoc test (HSD) to determine the significantly different mean value among groups. The differences were considered significant at the $p \leq 0.05$ level.

RESULTS

The average working and setting time (seconds) of commercial VPS formulations at two different temperatures are shown in Fig 2 and 3 respectively. Increasing the temperature significantly decreased the working and setting time (p=0.03) of all the VPS impression materials tested. At 23ºC there was no significant difference (Tukey's HSD test) in the working time of Aq M and Extr M (p=0.02), which were significantly longer (p=0.02) than Elt M (Fig 2). Extr M had the highest mean working time at 23ºC (170 sec ± 9 sec) and Elt M the lowest mean working time (124 sec ± 8 sec).

At 37ºC the working time for Elt M was significantly shorter (60 sec ± 6 sec) than Extr M, with the exception of Aq M where the difference was not significant. Aq M and Extr M did not show any significant differences between their working time. Extr M had the longest mean working time (74 sec ± 5 sec) at 37ºC. At 23ºC and 37ºC, the Elt M demonstrated significantly shorter setting time, while Aq M and Extr M showed no significant difference (Fig 3).

DISCUSSION

The working and setting time of commercial VPS were investigated at 23ºC and 37ºC to simulate the temperature of dental surgery (23ºC) and patients mouth (37ºC) respectively. The working and setting time of all the materials were temperature dependent; an increase in temperature (from 23ºC to 37ºC), without changing any other factors, resulted in shorter working and setting time, due to a faster rate of polymerisation (Table 2). Similar results were found by Berg, Johnson 19 after investigating the setting characteristics of two VPS and five polyether impression materials. On comparing the results of the current study with Bonsor and Pearson[15] who investigated working and setting time of elastomeric impression materials (VPS, condensation silicone, polyether and polysulphide) at two different temperatures (23ºC and 37ºC), it was seen that all commercial materials of this study had lower working time compared to their VPS materials (Table 2). Another study by Pae et al (2008) also showed similar results with this study. They investigated the effect of temperature on the rheological properties of five VPS and one polyether impression material. They found that the these materials had different viscoelastic properties and most of the materials showed different fluidity at 21ºC and 33ºC.[25]

The vinyl polysiloxane (VPS) impression material is inherently hydrophobic. However, some manufacturer have incorporated surfactants within these materials and have classed them as hydrophilic VPS impression materials. The commercial VPS impression materials used in this study were hydrophilic according to the literature provided by the manufacturer. Previous studies have reported that the addition of a surfactant increases the working and setting time of silicone impression materials.[26] However, the materials evaluated in the current study showed their working and setting time were within the acceptable limits. It should be noted that the ISO4823[27], does not specify any working and setting time for elastomeric impression materials. They suggest one should refer to manufacture guidelines for working and setting time of these materials. However, according to the ADA[28], the maximum time for removal of the impression from patient's mouth should not be more than 10 minutes, but they do not specify whether the removal time includes working time.

Elt M's setting time was lower than Aq M and Extr M (Table 2). Therefore, it seems that the surfactant did not appear to affect setting time of Elt M. Elt M is sold as a hydrophilic impression material, but the latter property discussed implies that the surfactant incorporated is not as effective as those used in other materials (i.e. Aq M and Extr M). Hence, it is reasonable to infer that the addition of surfactant interfere with the setting of hydrophilic VPS materials.

CONCLUSIONS

- The working and setting time of VPS impression materials were temperature dependent; an increase in temperature resulted in shorter working and setting time without altering other factors.
- Elt M's working and setting time was lower than Aq M and Extr M.
- Addition of surfactant interferes with the setting of hydrophilic VPS impression material.

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CONTRIBUTIONS BY AUTHORS

ShahabnUd Din is the first author of this study, who searched the literature. He ordered materials from the suppliers, performed experimental work in the laboratory and collected the data and presented it in tables and figures. He also wrote the first draft and final draft after corrections made by the supervisor.

Muhammad Hassan helped in carrying out the experiments and refined the first draft written by first author. He also helped in using SPSS for data analysis of this study

Sandra Parker helped in developing methods for this study and experimental work. She also helped in proof reading of the final draft.

Mangala Patel was the supervisor for this study. She helped in developing experimental methods. She evaluated the results and statistical analysis. She refined the first draft written by first author and read the final draft.