

# Dimensional stability and weight changes of tissue conditioners

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## Summary

The dimensional stability of tissue conditioners characterizes the ability of the materials to yield accurate functional impressions of oral mucosa. This study evaluated the linear dimensional changes with time of 6 tissue conditioners (COE Comfort, FITT, GC Soft-Liner, Hydro-Cast, SR-Ivoseal and Visco-Gel) using a travelling microscope, and relationship between these changes and weight changes. The absorption and solubility of these materials were also determined. The percentage changes in dimension and weight in water storage were measured at 2 (baseline), 8 and 24 hours, and 2, 4, 7, 14 and 21 days after specimen preparation. All materials except SR-Ivoseal exhibited shrinkage and weight loss during water storage, whilst SR-Ivoseal exhibited expansion and an increase in weight. The percentage solubility for all materials except SR-Ivoseal was higher than the percentage absorption. A positive linear relationship was found between the percentage changes in linear dimension and those in weight ( $r = 0.797$  to  $0.986$ ,  $p < 0.05$ ). Water absorption and solubility of the materials were found to be associated with dimensional changes. The results suggest that the period recommended for forming functional impressions would be 24 hours after insertion in the mouth. In addition, it is important to select tissue conditioners suitable for functional impressions because of the wide ranges of dimensional stability among the materials.

## **Introduction**

Tissue conditioners can be used principally to treat abused mucosal tissues underlying ill-fitting dentures (Chase, 1961; Harrison, 1981). However, in addition, these materials are suitable for a functional impression (McCarthy & Moser, 1978, 1984; Harrison, 1981). The effectiveness of tissue conditioners as functional impression materials depends on their viscoelastic properties (Wilson, Tomlin & Osborne, 1966; Murata *et al.*, 1998), compatibility with gypsum products (McCarthy & Moser, 1984; Panagiotouni *et al.*, 1993) and reproduction of detail (McCarthy & Moser, 1978). Dimensional stability is also considered to affect the capacity of the materials to develop accurate impressions.

Tissue conditioners generally consist of poly (ethyl methacrylate) or a related copolymer (Jones *et al.*, 1991) mixed with a liquid compounded of an ester plasticizer and ethyl alcohol (Jones *et al.*, 1988). The esters are generally aromatic esters such as butyl phthalyl butyl glycolate, dibutyl phthalate, benzyl butyl phthalate and benzyl benzoate. The concentration of ethyl alcohol is commonly between 5 and 20 wt%. However, the liquid of some commercial material is composed of dibutyl sebacate, which is aliphatic ester, and approximately 50 wt% ethyl alcohol. These materials undergo two processes when immersed in water: ethyl alcohol and plasticizers are leached out into the water, and water is absorbed by the polymer (Braden & Causton, 1971; Kalachandra & Turner, 1989; Jones *et al.*, 1988). These processes can affect the compliance, flexibility, viscoelastic properties of the materials, surface roughness of dental stone cast from them, and dimensional stability.

The purpose of this study was to evaluate the linear dimensional changes that occur in water over time, and relationship between dimensional stability and weight changes of tissue conditioners. In addition, absorption and solubility of these materials were measured and compared.

## **Materials and methods**

Six tissue conditioners were selected for this investigation (Table 1). Ten specimens of each material were prepared to 2 mm thickness (30mm long X 10mm wide) according to the manufacturers' instructions using a Teflon mould and two flat glass plates. The first five specimens were used for measurement of dimensional stability; the remaining five were used for that of weight changes.

### *Linear dimensional stability*

Metallic indicators (ball 0.5mm in diameter) were placed at a distance of 20mm on the surfaces of the specimens. The measurement of linear dimensional changes of the materials with time was performed with a travelling microscope (Nikon Measurescope)\* with a resolution of 0.001mm. The distance between the two reference points of each specimen was measured by the same operator at 2 (baseline), 8 and 24 hours, and 2, 4, 7, 14 and 21 days after specimen preparation. The linear dimensional change of the tissue conditioner was expressed as a percentage using the following formula:

$$\text{Dimensional change (\%)} = (D - D_i) \times 100 / D_i$$

where D is the dimension of the tissue conditioner between the reference points, and  $D_i$  is the initial dimension (2 hours after specimen preparation) of the tissue conditioner between the reference points. The specimens were stored in distilled water at 37 °C except the measuring period.

### *Weight changes, absorption and solubility*

Specimens were weighed to an accuracy of 0.0001g at 2 hours after specimen preparation, and were placed into distilled water at 37 °C. They were removed, blotted dry and reweighed at 8 and 24 hours, and 2, 4, 7, 14 and 21 days after specimen

preparation. The weight change of the tissue conditioner was expressed as a percentage using the following formula:

$$\text{Weight change (\%)} = (W - W1) \times 100 / W1$$

where  $W$  is the weight of the tissue conditioner, and  $W1$  is the initial weight (2 hours after specimen preparation) of the tissue conditioner before water immersion.

Furthermore, the percentage absorption and solubility of the tissue conditioner at 21 days after specimen preparation were determined as follows:

$$\text{Absorption (\%)} = (W2 - W3) \times 100 / W1$$

$$\text{Solubility (\%)} = (W1 - W3) \times 100 / W1$$

where  $W2$  is weight after absorption and desorption, and  $W3$  is final weight after desiccation. The specimens were dried in a desiccator containing silica gel until a constant weight ( $\pm 0.5\text{mg}$ ) was obtained.

### *Statistical analyses*

Two-way ANOVAs were performed to find whether statistically significant differences were present between materials and times for linear dimensional changes and weight changes. The differences of these values among materials were tested with the Student-Newman-Keuls test at a 5% level of significance. Comparison of the percentage absorption and solubility was subjected to a one-way ANOVA and mean values were compared with the Student-Newman-Keuls test at a 5% level of significance. T tests were also used at a 5% level of significance to evaluate differences between the percentage absorption and solubility of each material.

Regression analyses were used to determine the relationship between the linear dimensional stability and the weight changes of each material.

For all statistical analyses, the SPSS software (SPSS Inc., Chicago, USA) was used.

## **Results**

ANOVA results indicate significant differences among the materials and significant effects of time of storage for the linear dimensional changes and the weight changes.

Figure 1 shows the linear dimensional changes with time for 6 tissue conditioners in water storage. All materials except SR-Ivoseal showed a decrease in mean percentage change in linear dimension (shrinkage) during water storage. The greatest mean percent of shrinkage was recorded for COE Comfort. SR-Ivoseal showed a decrease in percentage change in linear dimension until 8 hours of water storage, and then this material increased in percentage change in linear dimension (expansion) from 8 hours to 21 days of water storage. No significant differences were found among the percentage changes in linear dimension of all the materials at 24 hours, however, the difference in the value among the materials increased with time (Fig. 2).

Figure 3 shows the weight changes with time for 6 tissue conditioners in water storage. All materials except SR-Ivoseal showed a decrease in weight during water storage. The greatest and most rapid weight loss was recorded for COE Comfort, and the least and most gradual weight loss was for Visco-Gel. FITT, GC Soft-Liner and Hydro-Cast showed a rapid change in weight until 24 hours of water storage, and there was a gradual change in weight from 24 hours to 21 days of water storage. SR-Ivoseal showed a decrease in weight until 8 hours of water storage, and then the weight increased linearly with time<sup>1/2</sup> from 8 hours to 21 days of water storage.

Percentage absorption and solubility for 6 tissue conditioners stored in water for 21 days are indicated in Figs 4 and 5. There were marked differences in the percentage absorption and solubility among the materials. SR-Ivoseal had the highest percentage absorption (51.9%) and solubility (18.8%). No significant differences were found among the percentage absorption for GC Soft-Liner, FITT, Visco-Gel and Hydro-Cast, which were under 3.5%. These materials had significantly lower percentage absorption ( $P < 0.05$ ) than the other two materials. The lowest percentage solubility was recorded for Visco-Gel (4.0%). The percentage solubility for COE Comfort, FITT, GC Soft-Liner

and Hydro-Cast was significantly higher than the percentage absorption ( $P < 0.05$ ). Conversely, the percentage solubility for SR-Ivoseal was significantly lower than the percentage absorption ( $P < 0.05$ ). No significant differences were found between the percentage absorption and solubility for Visco-Gel.

Regression analyses of plots of the percentage changes in linear dimension against those in weight of the 6 tissue conditioners are illustrated in Fig 6. There was a positive linear relationship between the percentage changes in linear dimension and those in weight. The correlation coefficients ( $r$ ) ranged from 0.797 to 0.986.

## Discussion

The dimensional stability is important as a means to evaluate the physical properties required in order for a tissue conditioner to be used as a functional impression material. The results from this study have indicated the linear dimensional changes with time varied considerably with the tissue conditioners studied. All materials showed a smaller shrinkage (1.16% to 1.61%) at 24 hours of water storage. There was no significant difference between any of the materials. Then FITT, GC Soft-Liner, Hydro-Cast, Visco-Gel and especially COE Comfort exhibited shrinkage in linear dimension during water storage, whilst SR-Ivoseal exhibited expansion in linear dimension.

The weight changes with time, absorption and solubility values also varied considerably with the materials. COE Comfort, FITT, GC Soft-Liner, Hydro-Cast and Visco-Gel lost weight on storage in water, which was almost certainly due to the leaching out of the low-molecular-weight plasticizer and especially the loss of ethyl alcohol from the materials. Visco-Gel liquid contains a considerably lower percentage of ethyl alcohol (4.9wt%) and the higher-molecular-weight ester, butyl phthalyl butyl glycolate (mol.wt., 336) (Jones *et al.*, 1988), resulting in the least weight change and the lowest percentage solubility. COE Comfort and Hydro-Cast showed the greater weight loss and relatively high percentage solubility, probably because COE Comfort contained

the lower-molecular-weight ester, benzyl benzoate (mol.wt., 212) and powder/liquid ratios of both materials (0.9) were lower than those of the other materials. FITT, GC Soft-Liner and Hydro-Cast decreased in weight rapidly until 24 hours of water storage and subsequently decreased gradually. Jones *et al.* (1988) reported that ethyl alcohol was completely lost within 24 hours from tissue conditioners stored in water at 37 °C, and our results almost corresponded with their findings. The behaviour of SR-Ivoseal in water storage was quite different from that of the other 5 materials. Only SR-Ivoseal gained weight during water storage and had the very much higher percentage absorption of water. This material also had the higher percentage solubility. SR-Ivoseal liquid contains a considerably higher percentage of ethyl alcohol (48.1wt%) than the other materials and a straight chain non-aromatic ester, dibutyl sebacate (Jones *et al.*, 1988), resulting in the higher absorption and solubility.

This study has demonstrated that there was a positive linear relationship between the linear dimensional changes and weight changes of tissue conditioners. Leaching out of ethyl alcohol and low-molecular-weight plasticizer into the water would be associated with shrinkage, and expansion would be caused by absorption of water. It was expected that shrinkage of tissue conditioners would occur when the percentage solubility was higher than the percentage absorption, and that conversely the expansion would occur when the percentage absorption was higher than the percentage solubility. The difference between the percentage absorption and solubility for Visco-Gel was almost the same, resulting in the least weight change with time among the materials tested.

Tissue conditioners have been used to treat abused tissues and make functional impressions (Chase, 1961; Harrison, 1981). However, these materials are incapable of performing these dual purposes on the basis of viscoelastic and chemical properties (Wilson, Tomlin & Osborne, 1969; McCarthy & Moser, 1978; Murata *et al.*, 1998). Our finding on the basis of dimensional stability is agreement with these views, because a wide range of dimensional changes with time were found among the materials. Some



materials may be not suitable for functional impression making. Mainly rheological properties are specified by international standards for these materials. Therefore, international standards for tissue conditioners when used as functional impression materials should be developed.

When a tissue conditioner is to be used as a functional impression material, a material should flow readily by means of functional stresses and register the accurate shape of the oral structure (McCarthy & Moser, 1984; Murata *et al.*, 1998). Although the flow property of this material would compensate in part for the dimensional changes and produce a close adaptation to the denture foundation area at the clinical situation, the material with smaller dimensional changes is adequate to the functional impression making. From the point of view of dimensional stability, FITT, GC Soft-Liner, Hydro-Cast and Visco-Gel materials would be more suitable for functional impression making because these materials behaved in the more stable manner dimensionally. For all materials, smaller shrinkage was observed between 8 and 24 hours. Furthermore, no significant differences in shrinkage were noted among the materials after 24 hours. To obtain precise information on the denture foundation area under functional conditions and avoid the distortion of the impression surface when the denture is removed from the mouth and during subsequent laboratory handling, the denture containing the tissue conditioner would be left in the mouth for at least 24 hours before pouring the cast. During this time period, the elasticity of the materials reaches the sufficient value (Murata *et al.*, 1998). On the other hand, the tissue conditioners become harder and have less flow with time because of leaching out of the components contained in the liquid, especially ethyl alcohol (Murata *et al.*, 1996). These materials should not be used in the mouth for a long time. It would seem for these reasons that the period recommended for forming functional impressions would be 24 hours. This period may be more important factor than the selection of the materials. As stated previously, it is important to obtain a good understanding of dimensional stability of each tissue conditioner and appropriate

period of application as an impression material and to choose the material suitable for functional impressions.

### **Acknowledgement**

This research was supported by a Grant-in-Aid (No. 11671936) for Scientific Research from the Ministry of Education, Science, Sports and Culture, Japan.

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Fig. 1. Percentage changes in linear dimension with time for 6 tissue conditioners in water storage.

Fig. 2. Percentage changes in linear dimension for 6 tissue conditioners stored in water for 24 hours, 7 days and 21 days. Connecting bars indicate no significant difference ( $P > 0.05$ ).

Fig. 3. Percentage changes in weight with time for 6 tissue conditioners in water storage.

Fig. 4. Percentage absorption for 6 tissue conditioners stored in water for 21 days. Connecting bars indicate no significant difference ( $P > 0.05$ ).

Fig. 5. Percentage solubility for 6 tissue conditioners stored in water for 21 days. Connecting bars indicate no significant difference ( $P > 0.05$ ).

Fig. 6. Relationship between percentage changes in linear dimension and those in weight of 6 tissue conditioners.

Table 1. Tissue conditioners tested

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Code	Material	Manufacturer	P/L by Wt
CC	COE Comfort	GC America Inc., Chicago, Ill.	0.90
F	FITT	Sybron/Kerr, Romulus, Mich.	2.00
GS	GC Soft-Liner	GC Corp., Tokyo, Japan	1.22
HC	Hydro-Cast	Kay-See Dental Mfg. Co., Kansas City, Mo.	0.90
SI	SR-Ivoseal	Ivoclar AG, Schaan, Liechtenstein	1.50
VG	Visco-Gel	De Trey Division Dentsply Ltd., Weybridge, Surrey, England	1.21

Table 1

Fig. 1

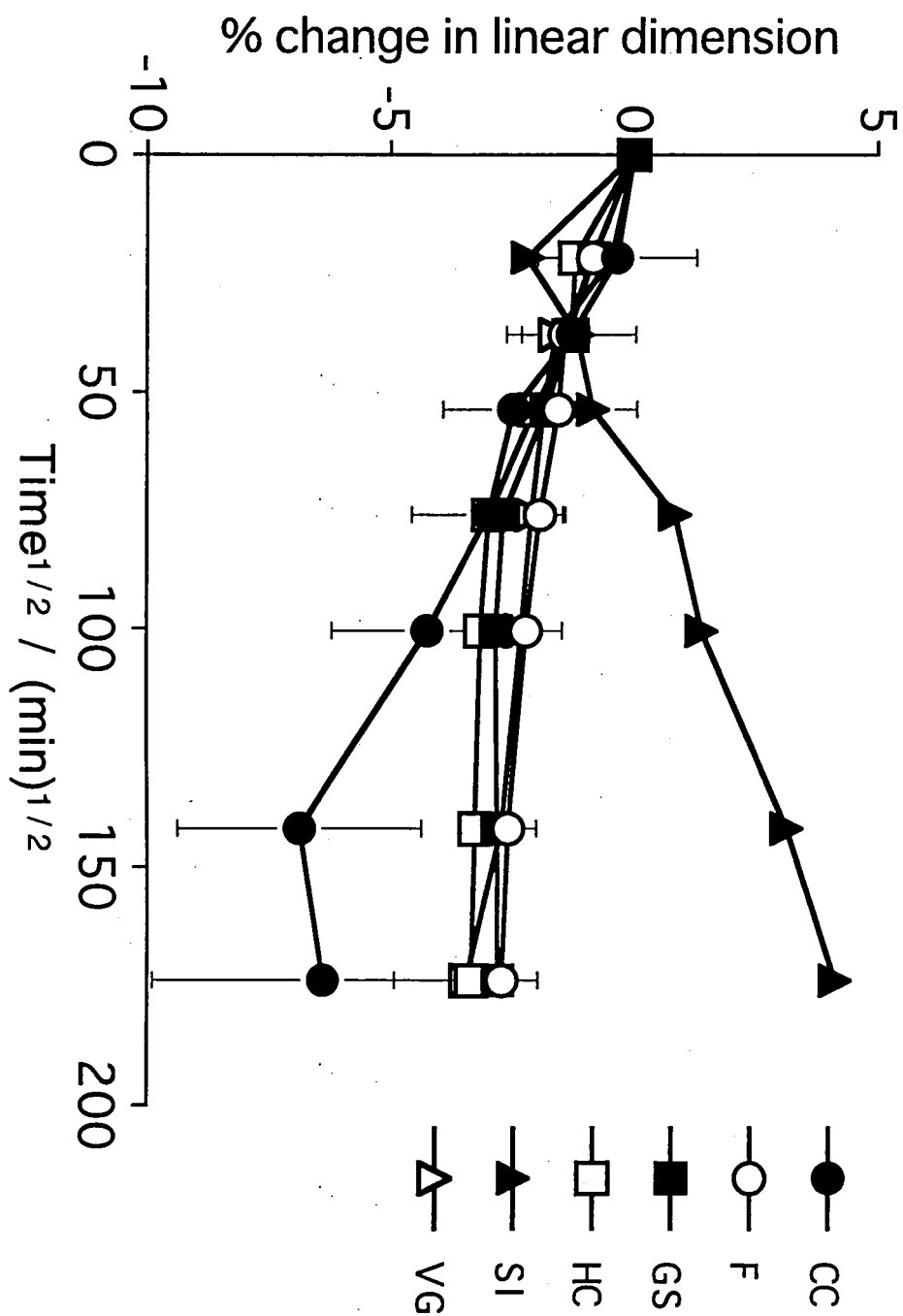


Fig. 2

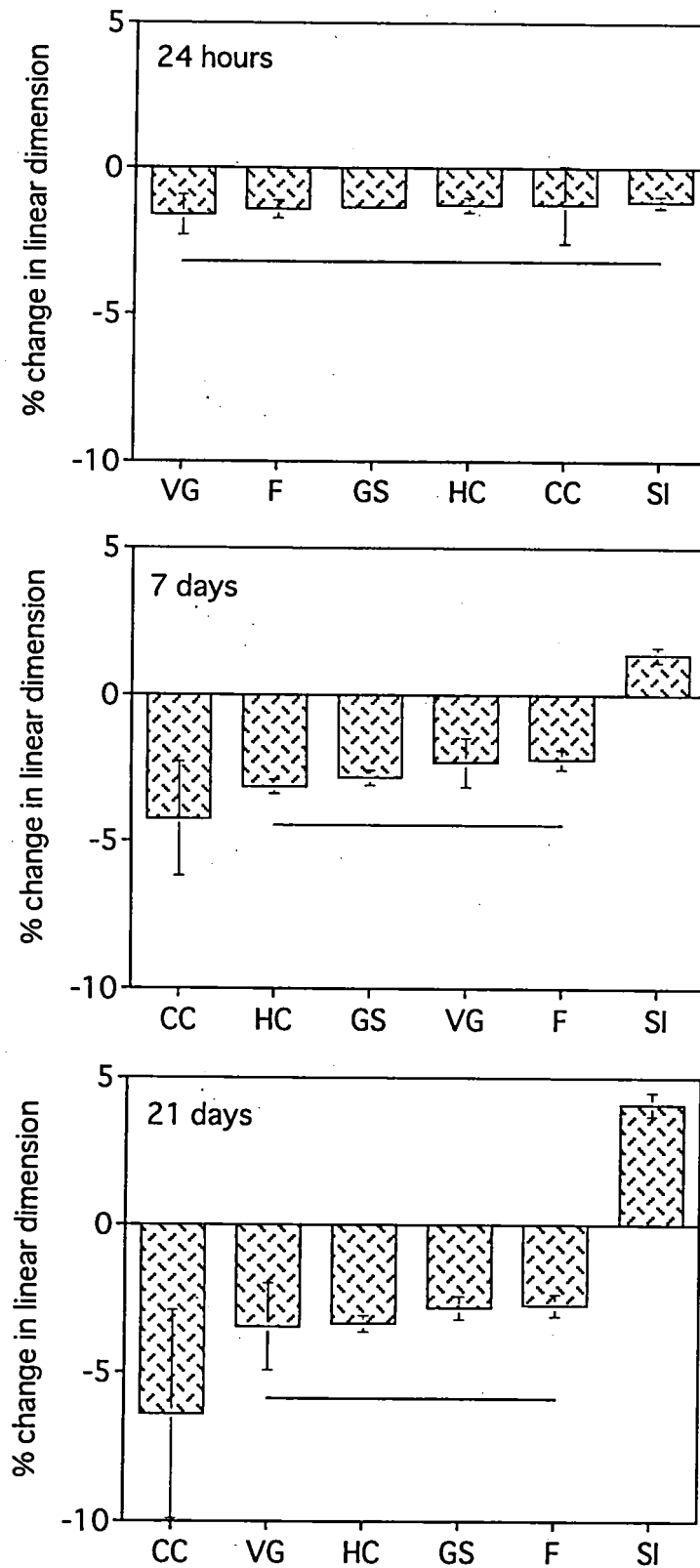


Fig. 3

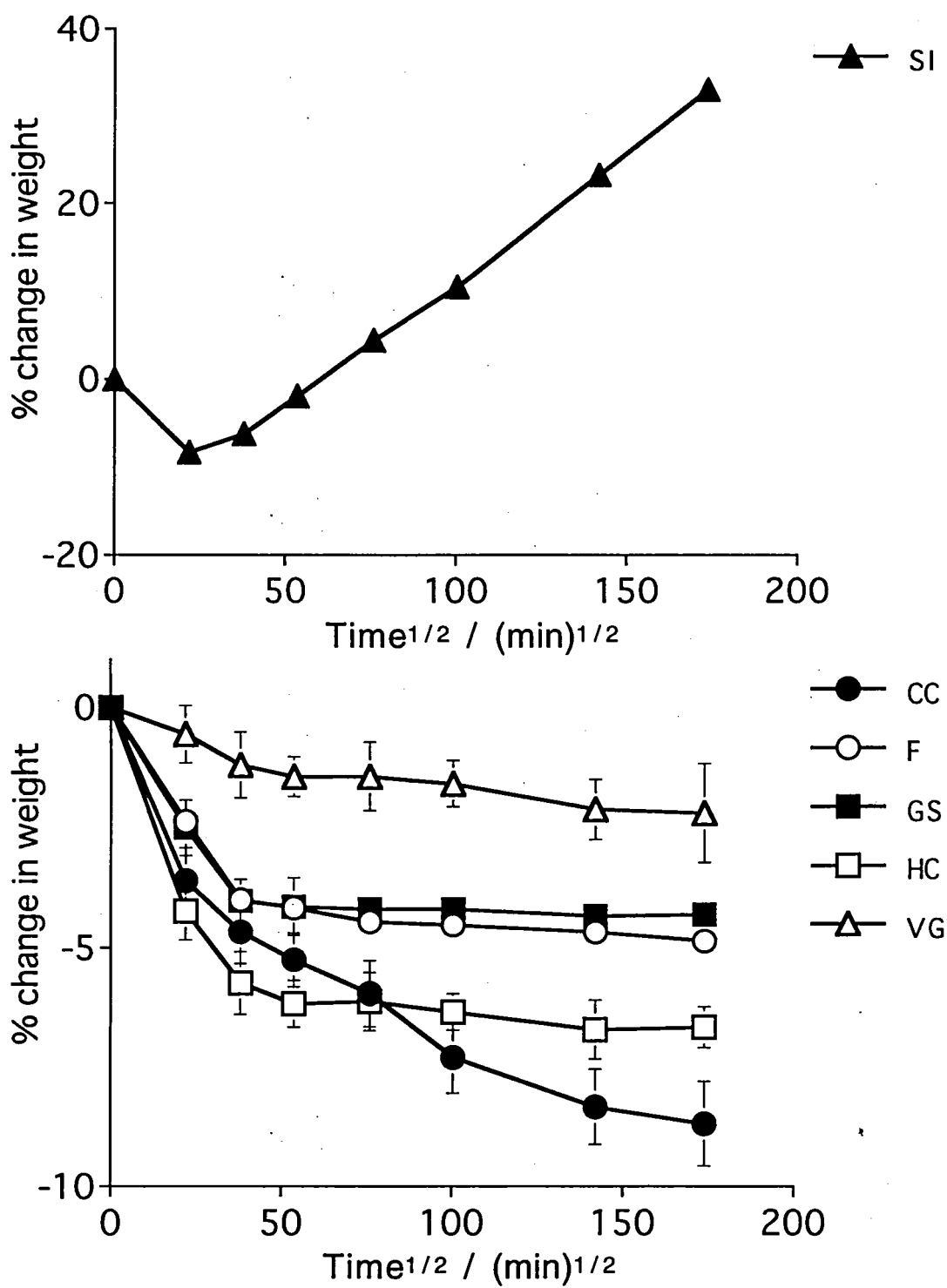




Fig. 4

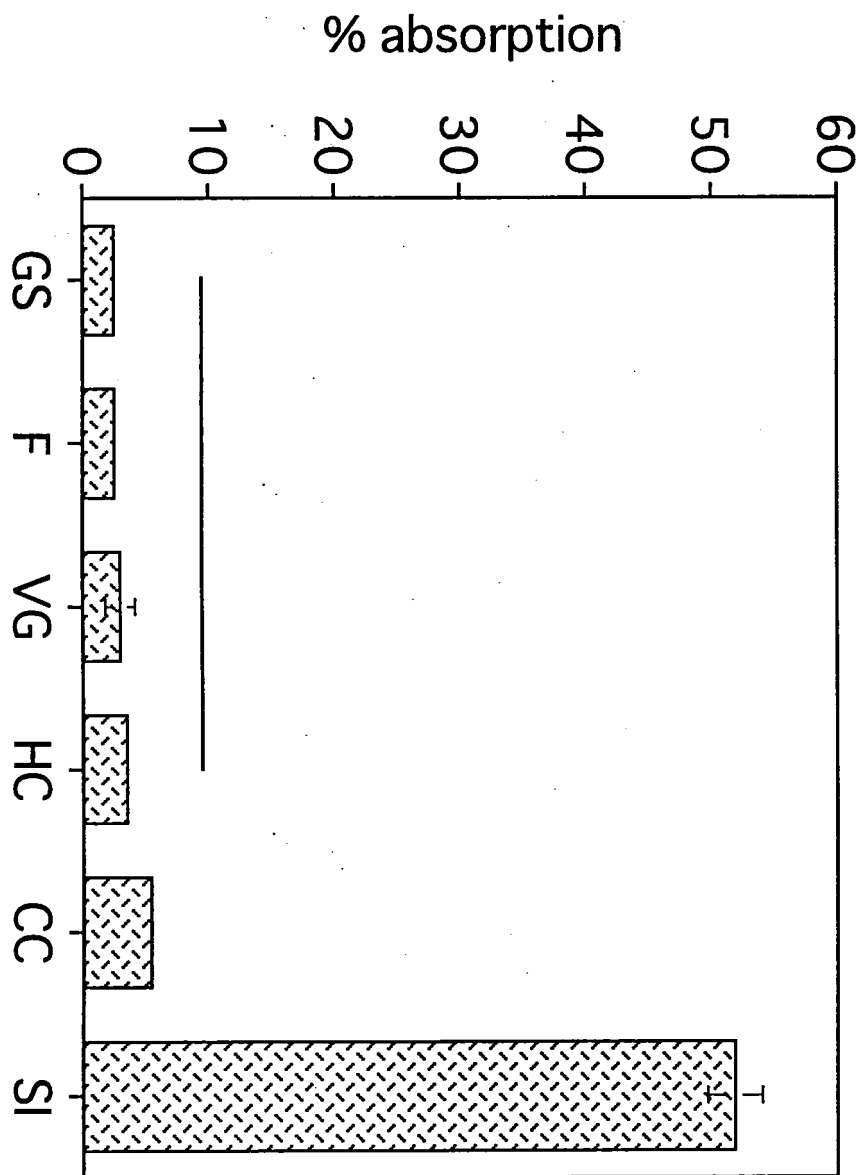


Fig. 5

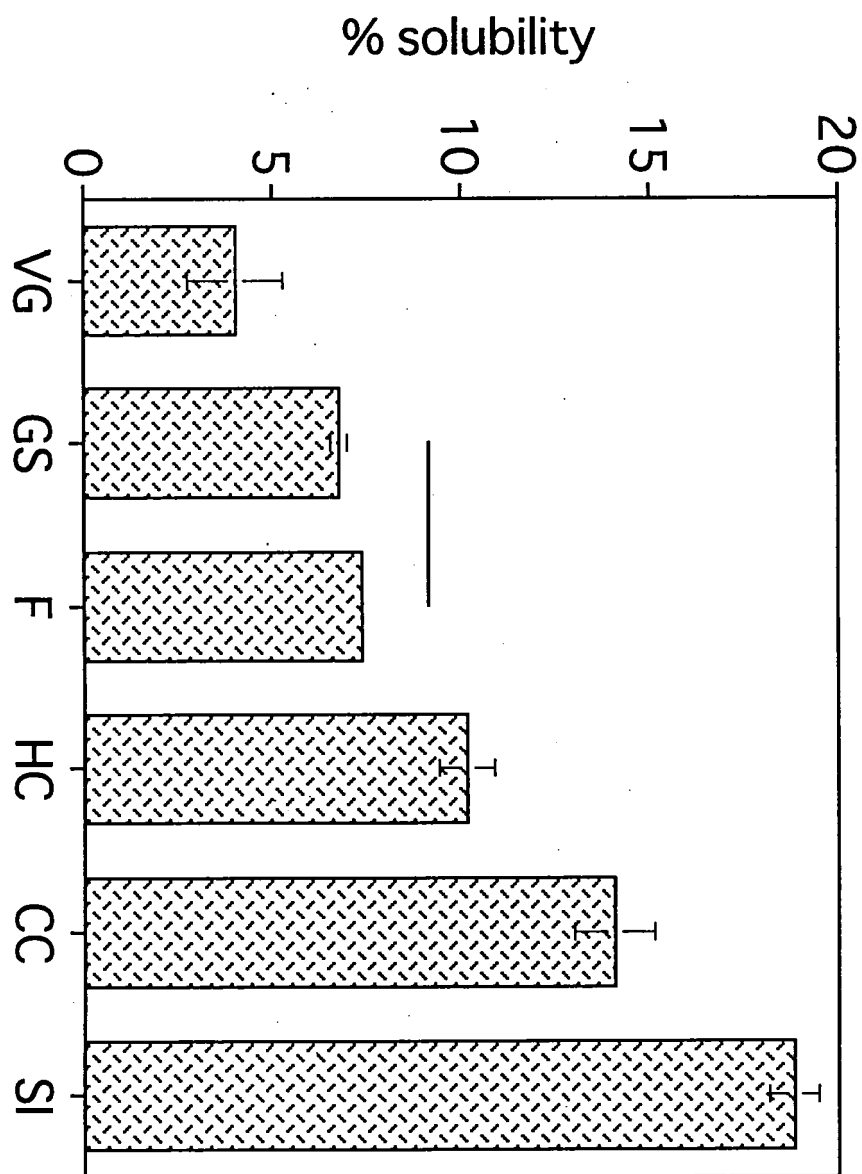


Fig. 6

