Impact of Storage Environments on the Dimensional Stability of Irreversible Hydrocolloid Alginate Impression used in Dentistry

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Background: Alginate impression material is widely used for recording accurate impressions to fabricate various oral appliances such as crowns, bridges, partial dentures and complete dentures. Alginate impressions are dimensionally unstable and hence it should be poured immediately to form exact cast. The impressions are sometimes sent to the nearby laboratories for making cast and models. For maximum dimensional stability, the cast should be poured immediately or it can be stored in lower concentration NaCl or K₂SO₄ solutions during transport to distant laboratories.

Objective: To evaluate the effect of various storage environments on the dimensional stability of irreversible hydrocolloid alginate impressions and to select a suitable medium for long time storage.

Materials and Methods: Alginate impression material is supplied in powder form and is mixed with distilled water and poured on cylindrical hollow plastic mold. After setting, the sample is removed, weighed and then stored for 24 hours in a) exposed to atmosphere at 28±2°C(60 ±5% relative humidity), b) refrigeration at 8±2°C, c) refrigeration in closed plastic sachets at 8±2°C, d) humidity chamber at 28±2°C and 8±2°C (100% relative humidity), e) distilled water f) solutions of NaCl at three different concentration and h) solutions of K₂SO₄ at three different concentration. The dimensional stability is measured by weight loss method and ion released during syneresis and imbibitions in storage media by using ion selective electrode method.

Results: Alginate impressions were more stable at lower concentrations of NaCl & K₂SO₄ and dimensional changes are less than ±0.6%. At higher concentrations more syneresis occurs, hence causes shrinkage of impressions. Impressions stored in open atmosphere showed maximum dimensional change followed by refrigerated sample, closed plastic sachets in refrigerator, humidity chamber and distilled water.

Conclusion: For maximum dimensional stability, the impression should be poured immediately with cast material or the impression can be stored 24 hours in lower concentrations NaCl or K₂SO₄ solutions during transport to distant laboratories. This can also be stored in humidity chamber or zip lock polythene sachets in refrigerator at 8±2°C up to 6 hours. This saves chair side time and helps to produce accurate results.

Keywords: Irreversible hydrocolloid, model and cast, syneresis, imbibitions, ion release, pH, dimensional stability.
INTRODUCTION
Irreversible hydrocolloid alginate impression material is widely used in dentistry for recording impressions accurately to obtain a model for diagnostic purposes, treatment planning, fabrication of provisional prosthesis, custom trays etc. The alginate impression materials are supplied in the powder form containing potassium or sodium alginate, calcium sulfate, tri-sodium phosphate, diatomaceous earth, potassium titanium fluoride, zinc oxide etc. When the powder is mixed with water a sol is formed through a reaction with sodium or potassium salts of alginic acid and calcium sulfate. After this chemical reaction alginic salts cross linked into a flexible matrix by replacement of the monovalent sodium and potassium ions by calcium ions.

Alginate impressions are dimensionally unstable due to syneresis and imbibitions. Hence it should be poured immediately to form exact cast. The factors affecting the dimensional instability of the alginate impression were studied by storing the impressions for two hours in solutions of gluteraldehyde (GA), NaClO, Na_2SO_4, CaCl_2, ZnSO_4 dilute 2% aqueous solutions of potassium sulfate and potassium chloride and recommended to use 2% aqueous solution of potassium sulfate for temporary stabilization. Dimensional changes of impressions are not only due to the immersions solutions but also to the impression components.

Supplementary changes of impressions are measured in detail by preparing standardized cylindrical specimens and stored in sodium chloride and potassium sulfate solutions at three different concentration, distilled water and storage conditions such as kept in open atmosphere, refrigerator and humidity chamber at controlled temperature. This is intended to find the most suitable storage medium and condition for use in clinical practices.

MATERIALS AND METHODS
In this study, Alginate impression material has been used, which is manufactured by Tropicalgin, lot A39979 (Italy), Sodium chloride, lot no - 193606.0527) (Merk) and potassium sulphate (lot no 7778-805) (Merk-India). Alginate powder of 8gm weight was mixed with 23ml of distilled water (20°C) for 45 seconds and emptied into a cylindrical ring of 23mm diameter and same height and placed on the glass plate. After 6 minutes, it is carefully removed, washed with distilled water, wiped with blotting paper and weighed immediately. This procedure is adopted for various samples and six samples were prepared for each group, which were stored for 24 hours in a) exposed to atmosphere at 28±2°C (68%±5% relative humidity), b) kept open inside refrigerator at 8±2°C, c) kept closed in zip lock polythene sachet in refrigerator at 8±2°C, d) humidity chamber at temperature 8±2°C and 28±2°C (100%±5% relative humidity).

| Time (Hours) | Ion released (Unit for Na & K-milli mole/litre and unit for Ca mg/litre) | pH of the solution at 28°C |
|--------------|------------------------------------------------------------------------|--------------------------|
| 1            | Na = 75, K = 1.4, Ca = 1.0                                           | 6.01                     |
| 24           | Na = 103, K = 3.6, Ca = 1.5                                          | 5.97                     |

Table 1 Ion released and pH by the Alginate gel in Distilled water
e) distilled water f) solutions of NaCl at different concentrations (0.05%, 2%, and 3%) and g) solutions of K$_2$SO$_4$ at different concentrations (0.02%, 0.2% and 1.0%). Dimensional changes were approximately measured by weight loss method as it is more related to clinical lab conditions. Graph is plotted by using the average values for each group. For theoretical considerations of syneresis and imbibitions, ions released were measured by selective electrode method and pH was measured by using pH meter.

**RESULTS**

Findings of the present study reveal, the linear dimensional changes (%) of sample stored in open atmosphere at 28±2°C, refrigerator at 8±2°C, closed plastic sachets in refrigerator at 8±2°C. Maximum syneresis occurred at lab temperature followed by refrigerator at 8±2°C,
closed plastic sachets in refrigerator at 8±2°C (Figure 1). The dimensional changes in 100% relative humidity chamber at different temperature and more negative dimensional change (i.e. syneresis) at higher temperature are shown in Figure 2. The linear dimensional change in distilled water is more than that occurs in lower concentration of 0.02% NaCl and 0.05% of K₂SO₄ (Figure 3). At lower concentration, NaCl and K₂SO₄ give smaller positive dimensional change (i.e. imbibition). But at higher concentration the percentage of dimensional change is more i.e. it shows more decrease in weight (syneresis) as indicated by negative values in the graph (Figure 4 & 5). The pH of the solution and ion released by alginate gel stored in distilled water at 1 hour and 24 hours is shown in the Table 1.

**DISCUSSION**

Exposure of impressions to air during
storage in open atmosphere, results in loss of water and accompanying increase in ion concentrations (probably K\(^+\), Na\(^+\), Ca\(^{2+}\) and SO\(_4^{2-}\)). The temperature and moisture plays a major role in syneresis as indicated by more dimensional changes in the samples stored in open air and in humidity chamber at lab temperature and which is lesser at lower temperature in humidity chamber. Loss of weight is more on refrigerator at 8±2°C compared to same conditions in humidity chamber, since the volume, enclosing the sample is less with later case. The sample stored in airtight sachets is more stable than that stored in refrigerator directly, indicated by less volume of air sachets, getting saturated more quickly.

In distilled water initially expands, because of the absorption of water to reach equilibrium. After few hours negative effect (decrease in weight) indicates that, heavier components from the gel are substituted with lighter constituents (H\(^+\) ions) of water. The decrease in pH of distilled water during storage indicates the release of H\(^+\) ions from the gel into the solution. After one hour storage in distilled water, Na, K, Ca ions are lost and positive dimensional change (increase in weight/expansion) indicates the excess water absorbed by reversible hydrocolloids.

The effects of storage in NaCl and K\(_2\)SO\(_4\) salt solutions can be understood by Hofmeister or lyotropic series in which ions of metallic salts can be arranged in order of their decreasing ability to precipitate lyophilic substances from colloidal dispersion (anion order: SO\(_4^{2-}\) > C\(_2\)H\(_5\)O\(_2\) > Cl->NO\(_3\)->ClO\(^3-\)->I->CNS; cation order: Mg\(^{2+}\) > Ca\(^{2+}\) > Sr\(^{2+}\) > Ba\(^{2+}\) > Li\(^+\) > Na\(^+\) > K\(^+\)).\(^6\) As the coagulation power/extent of coagulation/precipitation of gel is high (because of high concentration of ions/electrolytes), volume will decrease and thus shrinkage takes place. Although dimensional changes can be slowed by certain storage conditions, the importance of immediate pouring cannot be overlooked. Temporary surface stabilization can be achieved by immersion in dilute aqueous solution of 0.02% NaCl and 0.05% of K\(_2\)SO\(_4\) for 24 hours and also in humidity chambers and zip lock polythene sheets in refrigerator at low temperature up to 6 hours which shows minimal dimensional changes ±0.5%. Linear dimensional changes for these materials were within the limits of the ANSI/ADA specification.\(^7\) Long term storage in all conditions other than 0.02% NaCl 0.05% of K\(_2\)SO\(_4\) shows more dimensional changes which are clinically significant. Further studies need to be carried out to find out exact methods of volume changes, ion release in various storage media at different time and

![Figure 5](image-url)
factors affecting the dimensional changes of alginate gel.

CONCLUSION
For maximum dimensional stability, theoretically the cast should be poured immediately. If it is not possible the impression can be stored in 0.02% NaCl or 0.05% of K₂SO₄ solutions for about 24 hours, facilitating the shifting to distant laboratories from the clinics. This can also be stored in humidity chamber or zip lock polythene sachets in refrigerator at 8±2°C up to 6 hours. These have additional benefit of increasing surface hardness of the gypsum cast. The concentrations of these storage solutions will depend on various products and water powder ratio, which may be further studied in detail.

CONFLICTS OF INTEREST
None declared

NOTE
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