

# Breathing New Life into Alginates: A Journey of Reuse and Recycle

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Various impression materials are used in dentistry. One such material used is ALGINATE. It is an irreversible hydrocolloid. The term 'alginate' was coined from the term 'algin'. It is a polymer of anhydro beta D mannuronic acid of high molecular weight.<sup>1</sup>

1. ADA Specification-18; ISO 1563:1990<sup>2</sup>
2. TYPES (according to ADA Specification Number 18):<sup>3</sup>
  - TYPE 1 – Fast setting
  - TYPE 2 – Normal setting
3. APPLICATIONS OF ALGINATES:
  1. For making preliminary impressions for construction of custom tray for more accurate secondary impression for complete denture.
  2. Impression making for orthodontic purposes.
  3. For Duplicating models
  4. Used for impression making in presence of undercuts
  5. In impression making when there is excess of saliva
  6. For making impressions for fabrication of temporaries of for indirect restorations.
4. ADVANTAGES:
  1. Hydrophilic
  2. Easy manipulation
  3. Economical
5. DISADVANTAGES:
  1. Electroplating not possible
  2. Reuse is not possible
  3. Strength is poor

Among impression materials, dental alginate is used widely in dental practices. Thus the waste produced due to dental alginate is significantly large and adds to the medicinal waste generated all year round. Several methods of recycling alginate were experimented by various research institutes and students working in the dental field all over the world.

Due to increasing environmental problems such as variation in the climate air pollution and water pollution, this has become a serious problem all over the world.<sup>4</sup> In today's world the major cause of these environmental issues is the pollution from industries. Imposing regulations and penalties controls the pollution caused by such industries. There are the "three R's" put in place to save energy and make the ample use of resources. The three R's are reduce - recycle - reuse.<sup>5</sup> As the use of alginate is quite extensive in dentistry and it is not reusable for the making of impressions various efforts have been taken to try and reuse the used alginate in other forms.

**Various Methods to Reuse Alginate:**

**1. Use of alginate waste for creating an abrasive for polishing of denture base resin<sup>6</sup>**

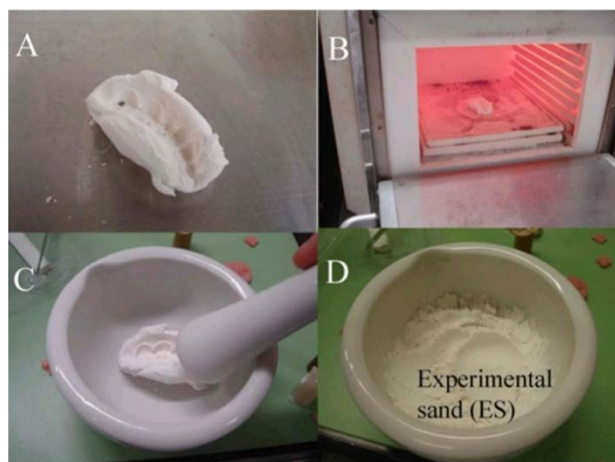
Diatomite powder from alginate impression and manufacturing of polishing rod from it and using it in polishing.<sup>7</sup>

The composition of alginate is as follows:<sup>8</sup>

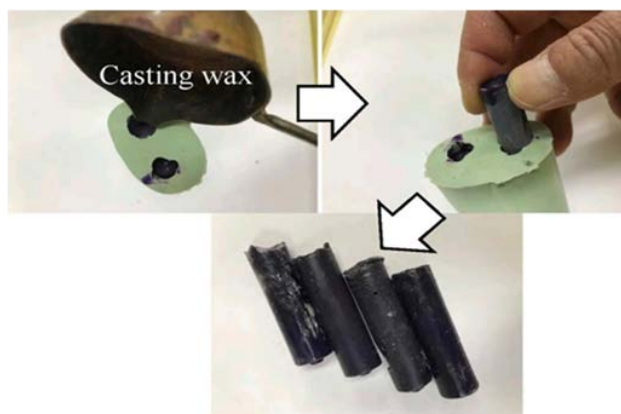
Ingredient	% By Weight	Function
1. Sodium potassium salts of alginic acid or triethanolamine alginate	15	Main reactive substance. Reacts with calcium ions in presence of water to form gel
2. Insoluble calcium sulphate	16	Forms calcium alginate by reacting with potassium alginate
3. Zinc oxide	4	filler
4. Potassium titanium fluoride	3	Gypsum hardener
5. Diatomaceous earth	60	filler
6. Trisodium phosphate	2	retarder

Ingredient	% By Weight	Function
7. Colouring and flavouring agents		Traces

Diatomite or diatomaceous earth makes up approximately 60% of the alginate impression material. Diatomite is supportive in as an abrasive agent in polishing of the denture base resin. Diatomaceous earth acts as a filler and does not actively play a role in the alginate reaction. Hence ever after use of the alginate the diatomite remains intact in the used product. Hence it is used to make a polishing tool. The alginate impression material was hardened a solid like lump was formed which was powdered. This powdering was done using a mortar and pestle. Some additional diatomite was added to make a final polishing agent. The result of this was such that diatomite was detected in the heated alginate material and it worked as a polishing material for the denture base resins.<sup>9</sup>



**Fig. 1** Experimental sand (ES) preparation  
A, obtained impression; B, firing; C, crushing; D, powdering



**Fig. 2** Preparation of the experimental polishing rod with ES

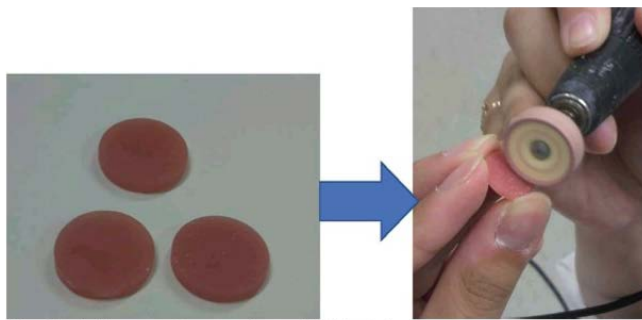


Fig. 3 Polishing experiment performed in this study

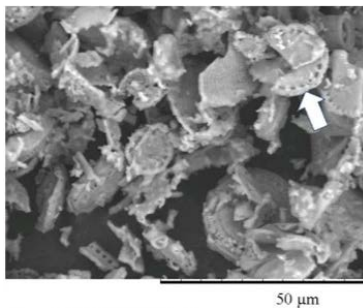


Fig. 4 SEM image of ES

The above images have been taken from Waki et. al. (Asian Pac J Dent 2021; 21: 1-6. doi: 10.47416/apjod.21-0278) the Asian Pacific Journal of Dentistry.<sup>7</sup>

#### Advantages:

1. Huge amounts of alginate are used in day to day dental practices and all this alginate can be recycled and reused to make a good abrasive product which can be used in the polishing of the denture base resin in a complete denture.
2. It also provides a good surface texture.
3. Improved aesthetics of the polished denture.

#### Disadvantages:

1. The surface texture although comparable with commercially available polishing products the surface gloss is not as effective as the gloss achieved with the commercial polishing agent.
2. A major risk factor which cannot be ignored is the occupational hazard related to the diatomaceous earth that is silicosis.<sup>9</sup>
3. There is a risk of lung cancer due to over exposure to the silica dust as diatomite has a presence of silica particles.<sup>10</sup>

## 2. Use of Dental alginate impression waste as a fertilizer and its effect on yield and soil quality.<sup>11</sup>

This research was done to check the viability of used alginate impression material as an additional crop fertilizer in the soil. It was also used to inspect the soil pH and determine the quality of the soil. The weight of the cauliflower crop was checked and compared when alginate was used as an additional fertilizer. Randomized block design method was used and 4 treatments and seven times replications were done.

As dental alginate is used widely and is not reusable, it is converted into waste which increases the waste production so various methods are being tested by which this waste can be reused productively. Dental alginate is converted into a fertilizer to check its efficacy as a fertilizer due to the presence of sodium potassium salts present and the calcium sulphate content present.

#### Advantages:

1. Increased weight of the plant when dental weight alginate was added
2. Increase in number of leaves in the plant.
3. Increase in diameter of the stem in the plant.
4. Increase in crop yields.
5. Due to the potassium content the root development was well and aids in opening and closing of stomata and ultimately leads to the increase in crop yield.

#### Disadvantages:

1. No effect on the quality of the soil
2. Bacteria such as salmonella spp and Escobar were present in the dental alginate waste. If these numbers exceed the permit limit they might contaminate the ground water source which is used by the community

## 3. Using used alginate for thermal insulation.<sup>12</sup>

The recycling of alginate for this is done by the process known as ionotropic gelation. In this process of recycling the pH is controls the chelating agent and disintegrates and reassembles the underlying matrix of the alginate composite. The functionality of this new product remains the same as the previous product

and intact. An alginate foam is made out of the recycled material. This foam develops as thermal and sound insulation system. This alginate base foam shows effective sound absorption and properties like thermal insulation. With this process alginate can be successfully recycled and the properties can be maintained and it can be used effectively.

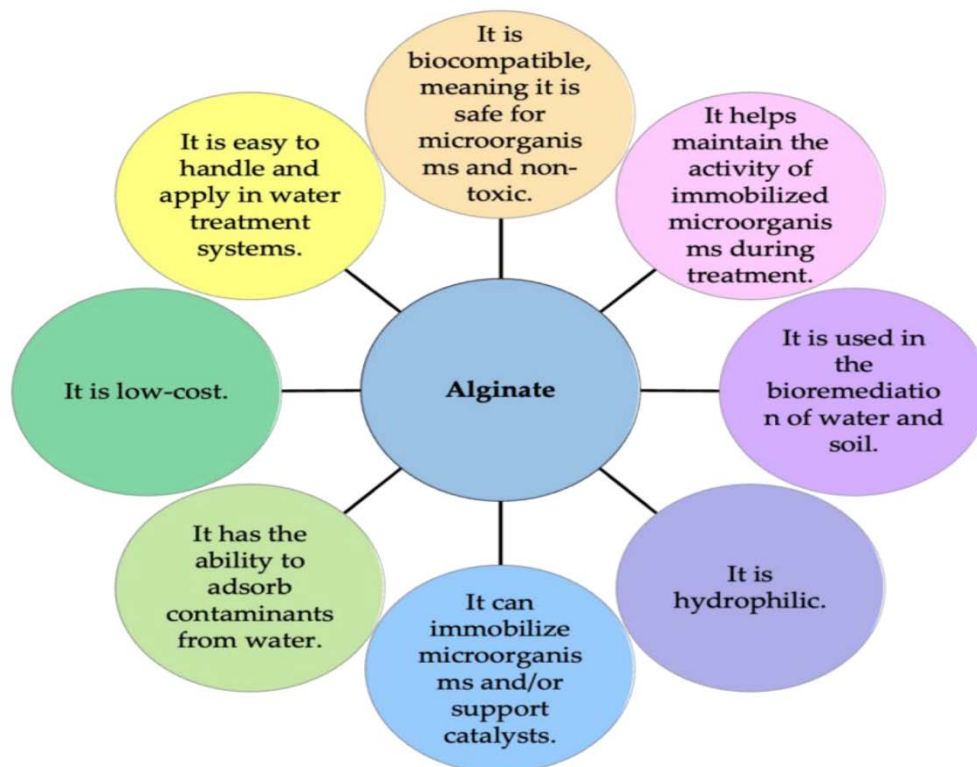
#### 4. Use of sodium alginate for recycling water by immobilizing the microorganisms present.<sup>13</sup>

This is deemed as an effective strategy for environmentally friendly solution for treating waste water. This mainly focuses on the relevance and effectiveness of use of sodium alginate in preserving the environment by the use of immobilizing the microorganisms present. The blend of sodium alginate with immobilizing organisms shows satisfactory

results with respect to water quality improvement and maintaining the ecological balance it also has certain challenges. Sodium alginate is chosen due to specific characteristics. This aids in balancing factors like toxicity, durability, mechanical resistance for aiding in the success of microorganism immobilization. Alginate has the property to form gels and are biocompatible as well. Alginate is responsible for forming coatings, the textile industry uses this property for its benefit.<sup>14</sup>

Challenges in this are:

- Alginate matrix should be checked thoroughly for deciphering the microorganism matrix interaction.
- Stability of sodium alginate in environmental conditions which are adverse.
- Sustainability of this immobilization technology



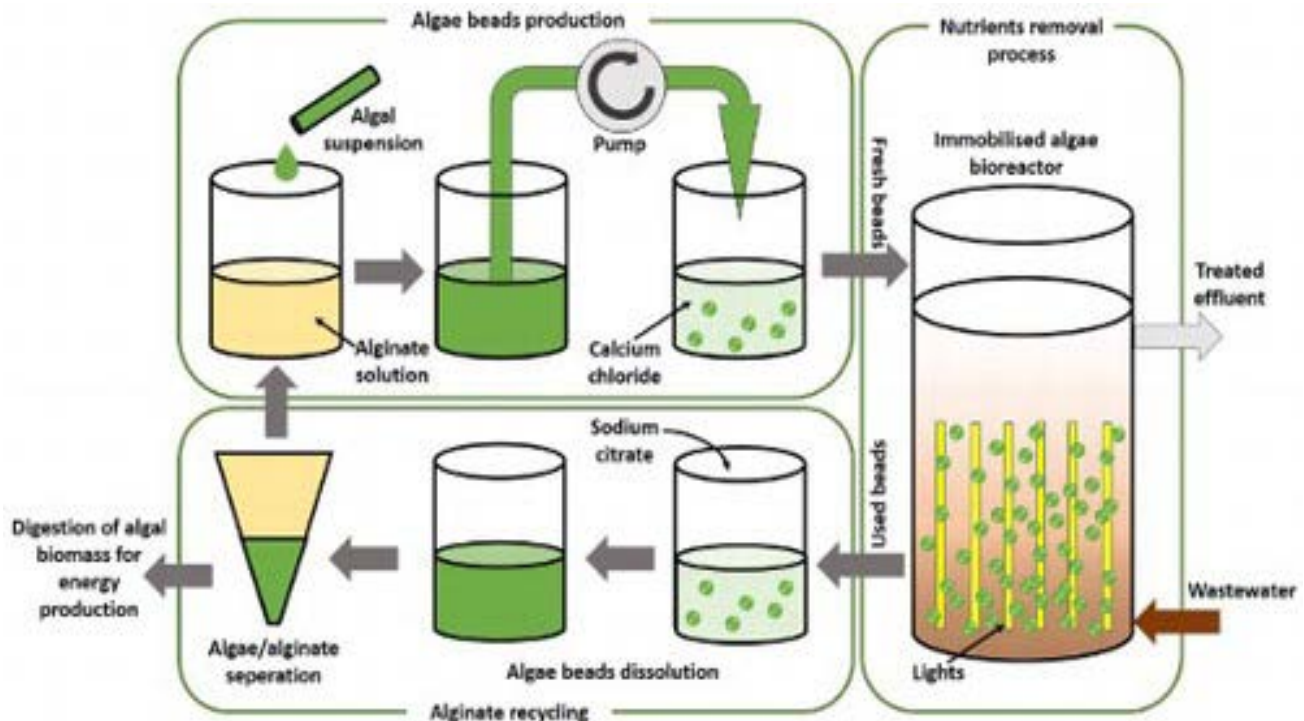
The image has been taken from: Bustos-Terrones, Y.A. A Review of the Strategic Use of Sodium Alginate Polymer in the Immobilization of microorganisms for water

### 5. Reusing alginate in an Algae Reactor.<sup>15</sup>

This is based on a technique which makes use of microalgae and removes the nutrients from waste water. This uses immobilized systems in which algae is entrapped in matrix of a polysaccharide like alginate. In this the dissolving agent used is sodium citrate.

This uses alginate recycling method and dissolving agent used is sodium citrate. The major disadvantage of this method is the cost in the up-scaling of gelling

agent alginate used in the alginate immobilized algae reactors. This can be made cost effective by the use of sodium citrate as the dissolving agent. Use of algae component from alginate that was recycled showed comparable results for removal of the compounds of phosphorous and nitrogen from the wastewater. Use of recycled alginate showed cost reduction of the entire process by approximately 60%.



### 6. Textile dye recycled using sodium alginate via means of double network polymer<sup>16</sup>

Sodium alginate used to photosynthesize and form double network polymers (DNP) and superabsorbent polymer (SAP). These were measured and compared using properties thermal stability morphological properties by scanning electron microscopy and mechanical properties. All these were considered for their dye absorption property. These were further considered at different temperatures and different pH values.

#### Materials used:

Vacuum distilled Acrylic acid, recrystallized potassium persulphate, sodium alginate, calcium sulphate,

trimethylolpropanetriacrylate (TMPTA) acetone, methanol, isopropanol, potassium hydroxide, sodium carbonate, reactive blue

#### Mechanism of crosslinking:

In sodium alginate the crosslinking of calcium ions occurs via L-glucuronate of sodium alginate and superabsorbent polymer. Carbon centered radicals are seen to have been formed during the irradiation of sodium alginate and SAP blend. This enhances the radical coupling.

#### Conclusion:

DNP of multiple forms were synthesized by using SAP and sodium alginate via their photo chemical crosslinking. It was found to be relatively stable

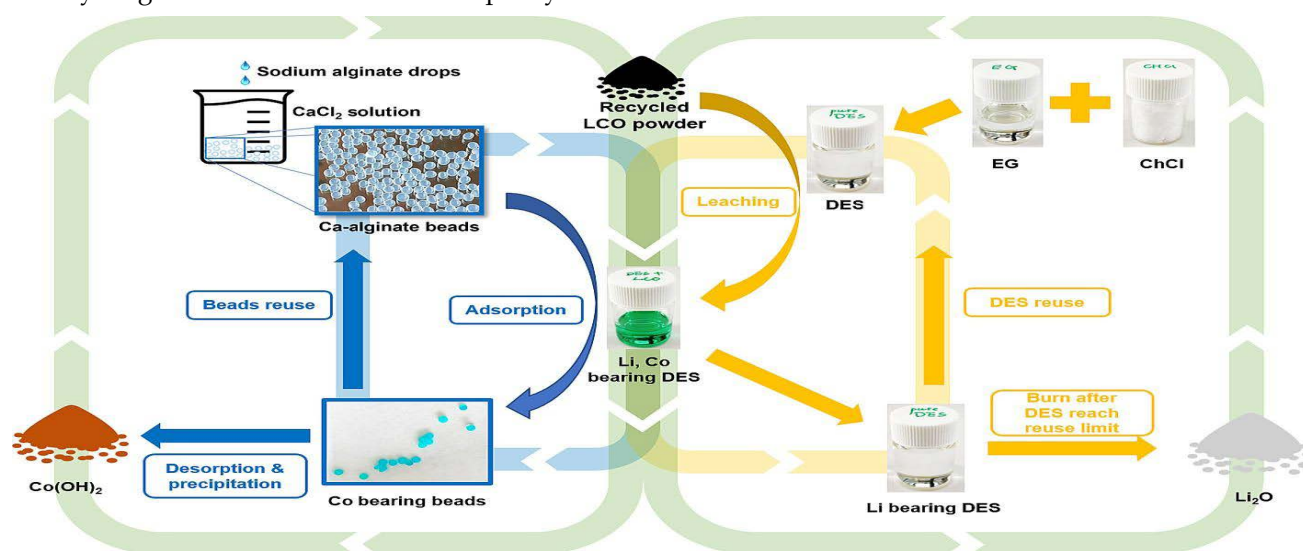
thermally. It could also cope with the normal environmental conditions. Thus the use of sodium alginate by means of double network polymer proved to be effective in recycling of textile dye.

### 7. Using natural and recyclable alginate hydrogels for recovering metals from spent batteries<sup>17</sup>

The need for batteries is increasing with manifolds and has increased apprehension about the raw material required for the same. Thus the recycling of lithium ion batteries by techniques which are methodical and environment friendly are necessary. Methods for recycling based on factors like purity level

high and low energy consumption and selectivity. For this using the deep eutectic solvent (DES) as leaching reagent and use of sodium alginate as adsorbent are chosen on the basis of their ability to be reused and availability and extent of biodegradation. Alginate is used as it can leachate 90% of cobalt in form of alginate hydrogels. Natural biopolymers as alginate hydrogels are biocompatible and non toxic and thus used for wastewater treatment and removal of ions such as  $\text{Cd}^{2+}$ ,  $\text{Cr}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Cu}^{2+}$

Thus this proves that alginate acts as an effective material in recycling lithium batteries.



### 8. Immobilization of amylase using alginate<sup>18</sup>

Amylase enzyme is seen to be used in industries such as textile, glucose syrup, sugar industry, paper, brewing industries as a catalyst. Amylase once used became a waste product. It was found that immobilization of amylase was a solution to this problem. It was seen immobilization enhanced the reuse of amylase. This also increased the shelf life of amylase. This immobilization was carried out using a sodium alginate matrix.

#### The parameters considered:

- Time of contact with sodium alginate
- The concentration of sodium alginate.

#### Mechanism of action:

- Entrapping the enzyme inside a gel matrix

#### Advantages of this technique:

- Contact between substrate and biocatalyst
- Relatively safe
- Straightforward and easy
- Cost effective
- Separation between product and enzyme easily obtained

#### Materials used:

Amylase obtained from *Aspergillusoryzae*, Sodium chloride, Distilled water, Sodium alginate, Starch, sodium hydroxide, citrate buffer solution, phosphate buffer solution, DNS (dinitro-salicylic)

#### Instruments used:

Autoclave, incubator, centrifuge, analytical balance, oven, shaker, scanning electron microscopy, pH meter

**Conclusion:**

Sodium alginate is used effectively in immobilization of amylase

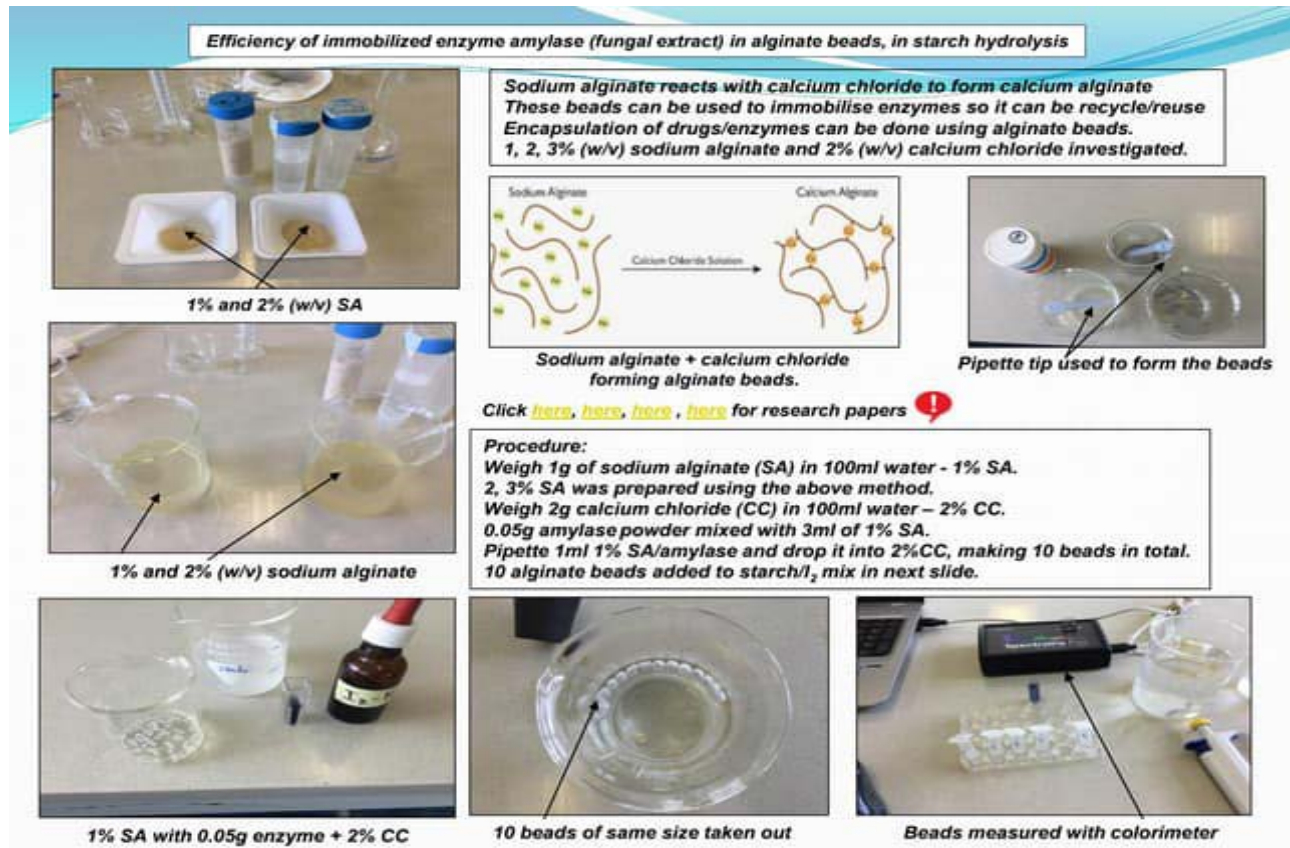


image source<sup>19</sup>

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