Eatable Water Bubbles Via Sodium Alginate And Calcium Chloride By Simple Chemical Reaction Method

Conference Paper · June 2020

H. J. Alesa
University of Babylon

Auda Braihi
University of Babylon

TEST Engineering & Management

March-April 2020
ISSN: 0193-4120 Page No. 22075- 22081

Eatable Water Bubbles Via Sodium Alginate And Calcium Chloride By Simple Chemical Reaction Method

Auda Jabbar Braihi[1], Hanaa Jawad[2], Asmaa Rashid[3]
[1,2,3] University of Babylon / College of Materials Engineering / Polymer and Petrochemical
auda_1964@yahoo.com[1], hanajawad21@yahoo.com[2], Asmaarh3@gmail.com[3]

Article Info
Volume 83
Page Number: 22075- 22081
Publication Issue:
March - April 2020

Article History
Article Received:19 October 2019
Revised: 27 December 2019
Accepted: 29 March 2020
Publication: 30 April 2020

Abstract:
In this study, an eatable water bubbles of sodium alginate (calcium chloride) were prepared by adding calcium chloride ($CaCl_2$) with different weight ratios (1, 3, 5 and 7) % to sodium alginate (NaAlg). The prepared bubbles consist of two layers: water as the inner layer and outer layer is the gel. Physical tests carried out on the water include PH, density, total alkalinity, as well as there are some other tests done for the gel include : biodegradability by soil burial test , morphological by scanning electron microscopy and atomic force microscopy (AFM) , in addition to thermal properties tested by differential scanning calorimetry (DSC). Results prove that the standard water properties were saved after packaging, which is between the ranges of water drinking properties. All samples degraded after standard short time by burial in the soil. Also, addition of $CaCl_2$ to the NaAlg decreasing the thermal transition points according to the results of DSC. While, the surface become smoother and with less cavities and voids as shown by the results of Atomic force microscopy. The results of Scanning electron microscopy proved that the overall structure of the bubbles were compact, well cross-linked, without noticeable defect, a basic one-phase microstructure, flat and smooth. The 5wt % cross-linker is optimum ratio according to the results of physical tests carried out on water.

Keywords: *Water Bubbles, Packaging, Eatable Bubbles, Sodium Alginate, Biodegradable film*

I. INTRODUCTION

Day by day, the global demand of plastic is rapidly increasing. Mostly, plastics are non-biodegradable or few are degradable but in a very slow rate [1]. Currently, the packaging sector is a major consumer in the most industries. Plastic packaging is being increasingly used in medical products and healthcare as well as in the beverages and packaged foods, but the use of plastic has disadvantage that becomes a major source of waste and pollution after use [2].

Burning plastics is also one of the available solutions to reduce pollution but usually produces some noxious gases like furans and dioxins, which are dangerous greenhouse gases and play an important role in ozone layer depletion [3].

Biodegradable packing is very important for a cleaner environment free from wastes of packaging materials. In recent years, natural polymers have been developed for the packaging and reduce the detrimental pollution [4].

On the other hand, the composites materials derived from bio based raw material represent important sources for biodegradable water packaging [5].

Alginates is an important materials for biodegradable packaging, and is a type of a linear polysaccharide of (1–4)-linked b-D-glucose a-Lguluronate units, which fabricated by different types of plants [6].

Cellulose is another material from plant origin used for producing biodegradable films for packaging, and is a linear polysaccharide of glucose residues put together via beta - 1,4 linkages. It is produced by verity types of plants [7].

Albeit, alginate based composites used for biodegradable packaging numerously, have desired mechanical properties, such as a high strength for improvement the mechanical properties of packaging film [8].

Cell wall of brown algae is the common sources for producing the alginate, also the alginate is extracted from seaweed for many purposes [9].

In 2014, Sirivio, J.A. et al., synthesized packaging materials by using alginate, cellulose and calcium cations (Ca^{+2}) as cross-linker. Results showed that the addition of micro and nano cellulose as reinforcement enhanced the mechanical properties of the alginate films significantly [10].

II. Experimental part :

2.1 Materials and Methods

Sodium Alginate as was purchased from HI Media laboratories Pvt. Ltd., Dindori, Nashik, India. White to yellow granular powder, has good water solubility.

Calcium Chloride ($CaCl_2$) with Molecular weight 110.98 g / mol. was purchased from Indian Company., Dindori, Nashik, India.

2.2 Preparation of Sodium Alginate Eatable Water Balls

The edible water balls were prepared by spheirfication method by immersing sodium alginate solution in a water bath of calcium chloride.

1- An appropriate amounts of sodium alginate powder (1 g) were added to 125 ml of water with continuous manual mixing for 15 min in room temperature to prepare sodium alginate solutions (solution 1).
2- Leave the solution for 30 min to remove any bubbles may generated during mixing.
3- Calcium chloride solution was prepared according to the following procedure:
   A. Grinding the calcium chloride molecules to powder.
   B. An appropriate amounts of calcium chloride powder (1g, 3g, 5g, 7g) were dissolved in 500 ml water to prepare calcium chloride solution (solution 2).
4. Drop solution 1 into solution 2 with a curved spoon and move the mixture for 5 min to activate the reaction and condense the sodium alginate into the form of a bubble.
5. Transfer the bubble formed by slotted spoon to bowl containing pure water to stop reaction and to remove of excess chloride.

2.3 Measurements

3-D morphology AFM images tested by Nano Scope IIIA Multi Mode AFM instrument. Differential scanning Calorimetric type SH1MADZ-4 DSC-60 used for thermal analysis of the samples. On the other hand, biodegradable test of alginate thin film was performed according to changing in weight loss percentage before and after burial in soil, eq.1 was used for calculating the weight loss percentage of samples as follows :

Weight loss % $=\{ (W_b - W_a) / W_b \times 100\}$ …(1)

Where W_b : weight before placement in soil;

W_a = weight after taken out and cleaned.

pH was tested according to ASTM D1293.

Volume density of water performed by using high precision density tester, type GP-120 S, due to ASTM D-792 .

III. RESULTS AND DISCUSSION

3.1 Characteristics of Water

Fig 1. a-b , displaying water properties after & before packaging, a. view water density before &

after of packaging, b. the pH of water before and after of packaging.

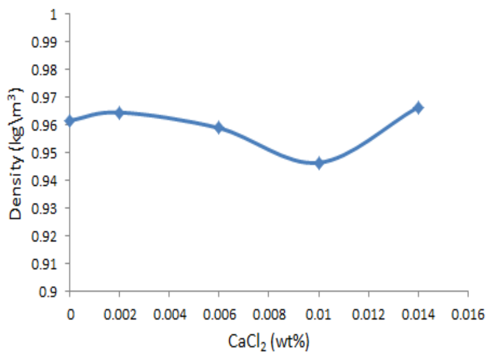


Fig. 1.a Density of water before & after

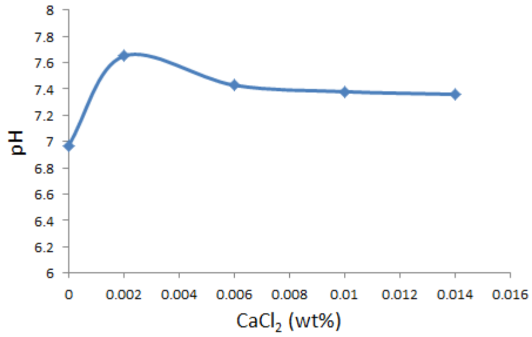


Figure1.b pH of water before & after packaging

Fig. 1.a-b Density and pH of water respectively

From fig 1.a-b, the stability of water properties (pH and density) can be noticed after packaging process. This suggest that no reaction has occurred between the water and packaging film materials [11].

Fig 2. show the alkalinity of water before and after of packaging. It is clear that the values of total alkalinity are within the acceptable range (80-120 ppm) of drinking water specifications. In addition, the values of alkalinity decrease with increasing $CaCl_2$ concentration. This is confirmed by the results of PH where the values of PH increased with increasing concentration of $CaCl_2$ [11-12].

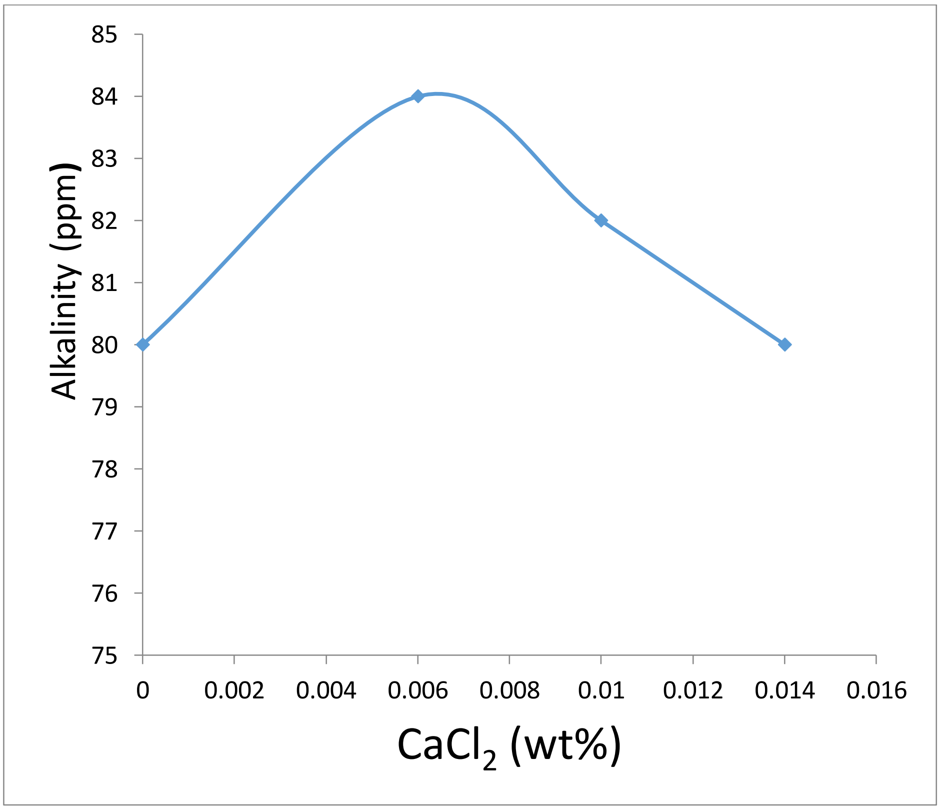


Fig. 2. Total Alkanet of all samples

March-April 2020
ISSN: 0193-4120 Page No. 22075- 22081

3.2 Characterization of Alginate Cover

Fig 3a-b. Show the 3D morphological pictures of biodegradable covering of water bubbles.

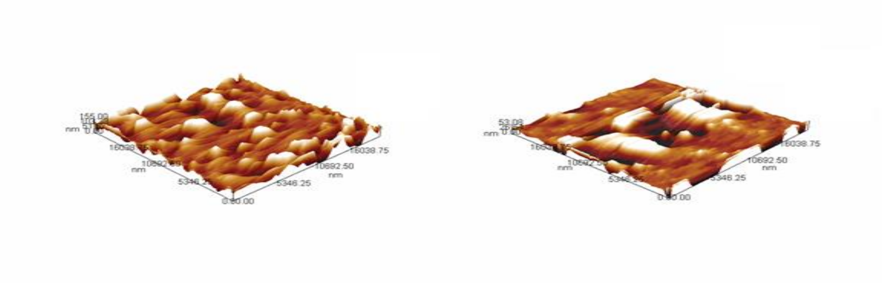
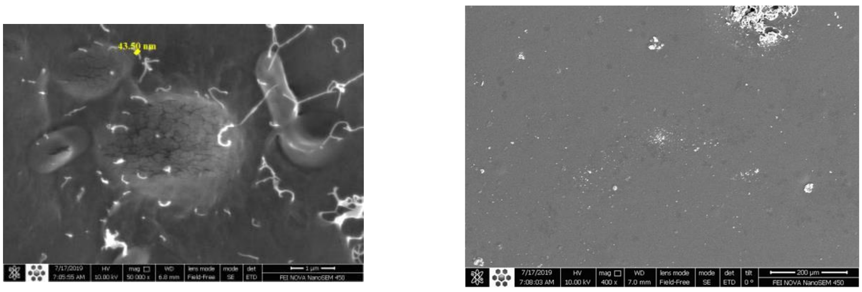


Figure 3.a NaAlg Figure 3.b bubbles

Fig. 3. AFM pictures of water babul cover

The results obtained from AFM test for NaAlg / bubbles (fig 3.a) showed that the core roughness depth (Sk) decreases by 64.18 % (from 55 to 19.7 nm) and the core fluid retention (Sci) decreased by 2.6 % (from 1.53 to 1.49). These surface changes enhance the surface bearing ability (Sbi) by 48.7 % due to increasing of the surface bearing index (from 1to 1.95) [13].

Fig 4 a-b Show the SEM images of biodegradable covering of water bubbles:



(a) NaAlg (b) bubbles

Fig. 4. SEM images of biodegradable covering of water bubbles

The morphology of the bubbles was analyzed by SEM. SEM images for NaAlg and bubbles (fig 4 a and 4. B respectively) show that the overall structure of the bubbles is compact, well cross-linked, without noticeable defect, a basic one-phase microstructure, flat and smooth. This is due to addition of $CaCl_2$ cross-linker to the sodium alginate solution entails the alignment of the G-blocks and the calcium ions are bound between the two chains like eggs in an egg box [14]. This is consistent with Ye, Z. et al., where prepared sustainable and natural film as a biodegradable alternative to conventional polyethylene films for packaging application by using sodium alginate, carrageenan and $CaCl_2$ as cross-linker. SEM pictures appeared that the location of alginate at the outside surface because it further hydrophilic than carrageenan. The general structure of the film is a single phase microstructure [13].

Fig 5 a. b show the DSC curves of pure sodium alginate and 5g $CaCl_2$ (cross-link ratio) eatable babbles water under N_2.The dehydration was evidenced by an endothermic peak close to 100°C, attributed to the water release. Then the decomposition of the biopolymer takes place represented by an exothermic peak at 240-260°C due to pyrolysis reaction, depending on the heating rate. Finally the decomposition of the carbonaceous material occurred above 300 °C [14].

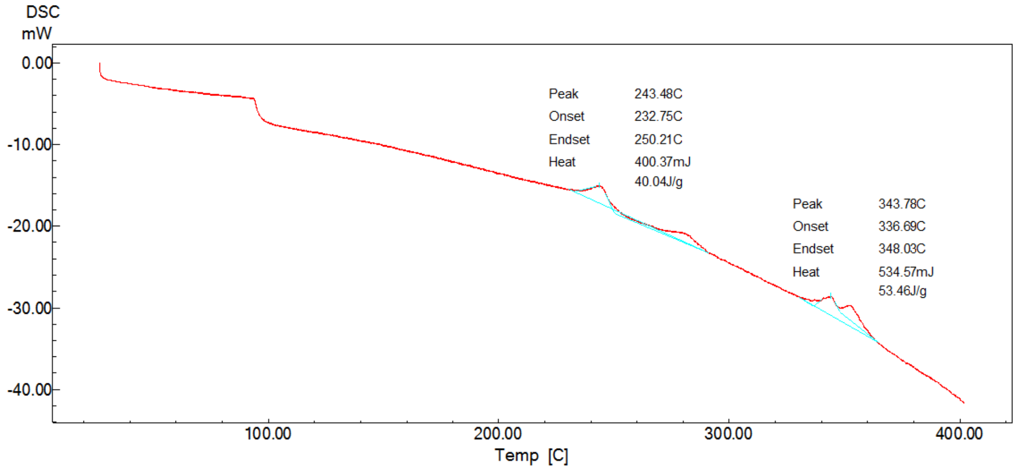


Fig. 5.a pure sodium alginate

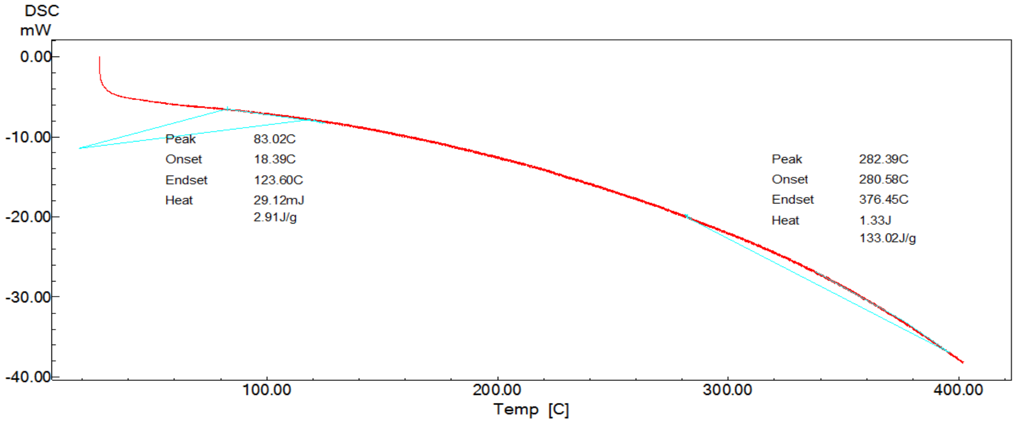


Figure 5.b 5g $CaCl_2$ (cross-link ratio) eatable water babbles.

Fig 6 show the biodegradable behavior via the soil burial test :

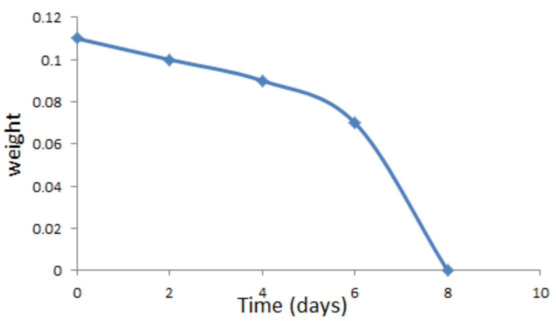


Fig. 6. Biodegradable behavior of water bubbles cover by soil burial test

TEST Engineering & Management

March-April 2020
ISSN: 0193-4120 Page No. 22075- 22081

Fig 6 presents weight loss as a function of biodegradation time and the presented photos of the studied sample before and during the test. Note that weight loss shows an approximately linear relation with degradation time and it was observed that the rate of degradation increased with increasing time. The weight started to decrease after 2 days of burial at a rate 9.09 % and it decreases gradually as the time increases with visible changes in the form compared to the initial state and after 8 days average weight decrease is 100%. As the microorganism attacks, the eatable water babuls lose their structural integrity. Certainly, the results obtained show that the eatable water bubbles will not cause any harmful ecological effect. In other words, the eatable water bubbles are completely biodegradable [15]. This is different with Solak, A. O. and Dyankova, S. M., where manufactured composite films from sodium alginate and high methoxyl pectin for packaging, coating of foods and pharmaceutical products purpose. Results showed that the films degraded to 80 days in the soil [16].

IV. CONCLUSIONS

The results obtained from this search suggest that the eatable water bubbles can be easily prepared by an available sources like sodium alginate and calcium chloride, the water can maintain its properties after covering via prepared alginate cover, which can degrade after short time by burial in soil. The bubbles are compact, well cross-linked and without noticeable defect by SEM characterization. The Results of AFM confirmed a decrease in surface roughness after adding of $CaCl_2$ and enhance the surface bearing ability. The best ratio of $CaCl_2$ was at 5wt% according to the results of physical tests carried out on water.

V. ACKNOWLEDGMENT

we would like to express our deepest appreciation to all those who provided us with the facility to complete this report, especially the materials engineering collage, polymer engineering department for their support to our paper.

VI. REFERENCES

[1] Olivia, W. "This Edible Water Blob Could Replace Plastic Water Bottles." Time. Time, 27 Mar. 2014. Web. 29 Sept. 2015. <http://time.com/40048/this-edible-water-blob-could-replace-plastic-water-bottles/>.

[2] Hope, M. (2003). Plastic Water Bottles Go to Waste, Says Calif. Conservation Agency. (industry News). Pla. Eng.. 59.7.

[3] Morales-Méndez, J .D. & Silva-Rodríguez, R. (2018). Environmental assessment of ozone layer depletion due to the manufacture of plastic bags. Heliyon, 4(12), e01020.

[4] Cruz-Romero, M. & Kerry, J.P. (2008). Crop-based biodegradable packaging and its environmental implications.CAB Rev.: Perspect. Agric.Vet. Sci., Nutr. Nat. Resour, 3, 1-25.

[5] Khalil, H.A, Bhat, A. H., & Yusra, A.I. (2012). Green composites from sustainable cellulose nanofibrils: A review. Car. Pol., 87(2), 963–979.

[6] Agulhon, P., Markova, V., Robitzer, M., Quinard, F., & Mineva, T. (2012). Structure of alginate gels: Interaction of diuronate units with divalent cations from density functional calculations. Biomacromolecules, 13(6), 1899–1907.

[7] Cheng, L. H., Karim, A. A., & Seow, C. C. (2008). Characterisation of composite films made of konjac glucomannan (KGM), carboxymethyl cellulose (CMC) and lipid. Foo. Che., 107, 411–418.

[8] Benavides, S., Villalobos-Carvajal, R., & Reyes, J. E. (2012). Physical, mechanical and antibacterial properties of alginate film: Effect of the crosslinking degree and oregano essential oil concentration. Jou. Foo. Eng., 110, 232–239.

[9] Khalil, H. P. S., Tye, Y. Y., Saurabh, C. K., Leh, C. P., Lai, T. K., Chong, E. W. N.& Syakir, M. I. (2017). Biodegradable polymer

films from seaweed polysaccharides: A review on cellulose as a reinforcement material. Exp. Pol. Let., 11(4), 244–265. doi:10.3144/expresspolymlett.2017.26.

[10] Sirviö, J. A., Kolehmainen, A., Liimatainen, H., Niinimäki, J. & Hormi O.E.O. (2014). Biocomposite cellulose-alginate films: Promising packaging materials. Foo. Che., 151, 343–351.

[11] Parameters of Water Quality : Interpretation and Standards, Environmental Protection Agency. (2001).

[12] Asadullah, A., Nisa, K. & Khan, S. I. (2013). Physico-Chemical Properties of drinking water available in Educational Institute of Karachi City. Sci., Tech. and Dev., 32 (1): 28-33.

[13] Ye, Z., Ma, P., Tang, M., Li, X., Zhang, W., Hong, Chen, X. & Chen, D. (2017). Interactions between calcium alginate and carrageenan enhanced mechanical property of a natural composite film for general packaging application. Pol. Bul., 74(8), 3421–3429. doi:10.1007/s00289-016-1894-x.

[14] Siddaramaiah, S., T. M. M., Ramaraj, B., & Lee, J. H. (2008). Sodium alginate and its blends with starch: Thermal and morphological properties. Jou. App. Pol. Sci., 109(6), 4075–4081. doi:10.1002/app.28625.

[15] Patel, A. , Panchal, T. , Thomas, M., Gupte, A. & Patel, J.(2016). Preparation and Characterization of Biodegradable Packaging Film Using Groundnut Protein Isolate. 24th European Biomass Conference and Exhibition, Amsterdam, The Netherlands.

[16] Solak, A. O. & Dyankova, S. M. (2014). Composite Films from Sodium Alginate and High Methoxyl Pectin-Physicochemical Properties and Biodegradation in Soil. Eco. Bal., 6 (2), pp. 25-34.