# Decolorization of Low Molecular Compounds of Seaweed by Using Activated Carbon

S. M. Anisuzzaman, Awang Bono, Duduku Krishnaiah, and Norazwinah Azreen Hussin

***Abstract*—Commercially available carrageenan powder which is extracted from seaweed possesses yellowish color and off-odor that deter their usage in human food, pharmaceutical and cosmetic industries. The objective of this study was to investigate of decolorization of low molecular compounds of seaweed using activated carbon (AC). The effects of changes on AC dosage, temperature and contact time were investigated. The effect of color concentration was analysed using Hunter Laboratories ColorFlex® Colorimeter. Colors were measured in reflectance mode using the Hunter L a b system, with D65 as the illuminant and a 10° standard observer angle. It was observed that an increase in activated carbon dosage decreases color. UV VIS Spectrophotometer was used to investigate whether adsorbed sample gives an effect to the molecular compounds before and after AC addition. In conclusion, the treatment using AC gives complete decolorization of carrageenan solution. This study also confirms contact time not really affected on bleaching process.**

***Index Terms*—Seaweed, carrageenan, semi refined carrageenan, adsorption, activated carbon.**

## I. Introduction

Seaweed is very common for people since the plant is rich in vitamins (vitamins B1, B2, B6, B16, C, and niacin) and minerals mainly calcium, sodium, magnesium, potassium, iodine, iron, and zinc [1], [2].

Carrageenan is well known also because of the low cost in production and nontoxic metal, sources of antioxidants, antimicrobials, and other bioactive agents. Carrageenan are the excellent source of bioactive compounds such as carotenoids, dietary fibre, protein, essential fatty acids, vitamins and minerals [3], [4] Besides, this can regulate with hormones to speed up the metabolism and promote a young looking skin color and well-being.

Nowadays, carrageenan extract is used in animal food and in industrial uses as stabilizer, gelling and thickening agent. Current commercially carrageenan powder possesses yellowish color and off-odor that deters their usage in human food, pharmaceutical and cosmetic industries as additive to improve food texture, gelation stability and viscosity.

Seaweed's cell walls contain polysaccharides, which include agar, alginates, carrageenans [1], and also minor compounds such as fucoidan and laminarin [5]. All the compounds have their own ability and roles such as, capacity to form gel, metal chelating, and other actions.

Agar can be defined as a hydrophilic colloid extracted from certain seaweed from the Rhodophyceae class and it is insoluble in cold water but soluble in boiling water. It is a mixture of polysaccharides which is the basic monomer of galactose and it can be sulphated in very variables degrees but to lesser degree than carrageenan [6].

Extraction process act to removes coloring matter and some proteins and makes the gum more easily extractable. 6-sulfate may also eliminate in some extraction process. Basket of seaweed immersed and cooked in alkali solution and then soaked with fresh water to naturalized most of the residual alkali [7]. *Kappaphycus alvarezii* (*Euchema cottoni*) is used in this process because it contains mainly kappa (*k*) carrageenan and this is the carrageenan that forms a gel with potassium salts. Iota-containing seaweeds can also be processed, although the markets for iota (*i*) carrageenan are significantly less than those for kappa. Lambda (λ) carrageenans do not form gels with potassium and would therefore dissolve and be lost during the alkali treatment [8].

Activated carbon was first known to treat water over 2000 years ago. However, it was first produced commercially at the beginning of the 20th century and was only available in powder form. Initially activated carbon was mainly used to decolorize sugar and then from 1930 for water treatment to remove taste and odor [9].

The adsorption power of the AC is in the range of 90% - 110% of the declaration value [10]. Besides, activated carbon is economically saved because of its low price but its cost is not too low enough to a large consumption of adsorption sites other than the intended compound to be removed [11]. As mention by Jensen, B., 2009, the AC is widely used because of it is a low cost adsorbent [12].

Decolorizing applications involve removal of large molecular compounds which require AC with a well-developed macropore structure [13]. AC is employ as a color removing agent (adsorbent) due to its economic advantage over other adsorbents. It finds wide application in food, pharmaceuticals, solvent recovery, drinking water treatment, fuel cells, chemical and other process industries [14]. AC is non-specific adsorbents that not only bind the color components, but also the protein components and odor components [15].

The aim of this study was to investigate decolorization and deodorization of low molecular compound of seaweed by using AC. Therefore, color concentration analysis was

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conducted to observed influence of AC dosage and contact time.

## II. Materials and Methods

### A. Preparation of Raw Seaweed

Raw seaweed, *Kappaphycus alvarezii*, was collected from UMS Seaweed Research Farm, Semporna which prepared by sun drying. Sundried seaweed was washed thoroughly with distilled water for two reasons; to remove contaminants and to standardize the moisture content of the seaweed. Wet seaweed was then dried in oven at $60^0$C for 15-16 hours to remove the excess moisture [7], [16].

### B. Extraction of Seaweed

The dried seaweed was extracted in batch cooker in potassium hydroxide (KOH) solution. The extraction temperature, KOH concentration and extraction time were controlled at 75 ℃, 74.70 min and 6.70% KOH concentration. The extracted seaweed was then cooled to room temperature and washed with distilled water to remove the excess KOH [17]. This processed seaweed was classified as semi refined carrageenan (SRC).

### C. Adsorption Procedure

The AC granules were sieved to remove fine carbon powder and were dried overnight in oven at $100^0$C. Various ratios of activated carbon were weighed into flask with 200 mL of sample. All the flasks were then sealed shut with aluminum foil. Each flask were shaken and immersed at water bath with 50 rpm for desired value of temperature and contact time. After shaking with manipulated temperature, the contact time was stopped, then the AC settled and the liquid of sample was decanted into graduated cylinder to measure volume recovered. Measuring the decanted volume ensures an accurate concentration of the seaweed gel solution calculation [18].

### D. Removal of Activated Carbon from Decolorized Solution

The granulated AC from decolorized solution settled at bottom of flask was screened at laboratory lab (ASTM standard, No: 20, nominal sieve opening: 0.850 mm) and used to sieve AC after adsorption process [17].

### E. Color Concentration Analysis

For color analysis, 25 ml of adsorption sample was put on the glass sample cell and the reading showed on the screen display and was recorded as a result. A Hunter Laboratories ColorFlex® Colorimeter was used to quantify the color of the carrageenan solution. This colorimeter gives reading of 3-dimensional rectangular space with D65 as the illuminant and $10^0$ standard observer angles [18].

### F. UV-VIS Spectrophotometry Analysis

A total of 0.1 ml sample was diluted to 1.5 ml with $H_2O$, and then this mixture was spiked with 1 ml phenol (5%) and 4 ml $H_2SO_4$. Color reaction was performed at 30 ℃ for 35 min. Spectrophotometry conditions in the assay was 200-600 nm as its full-scan wavelength, with the slow scanning speed 2 nm as the broadband spectrum and 488 nm as the detection wavelength [19].

## III. Results and Discussion

### A. Data Analysis

The data was entered and analysed into Microsoft Excel (Microsoft Corporation, Redmond, USA) CIE-Lab values were used to calculate a value for color change ($\Delta E$) by using the following equations [20]:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (1)$$

The $\Delta E$ between initial or reference with the final colors was then calculated.

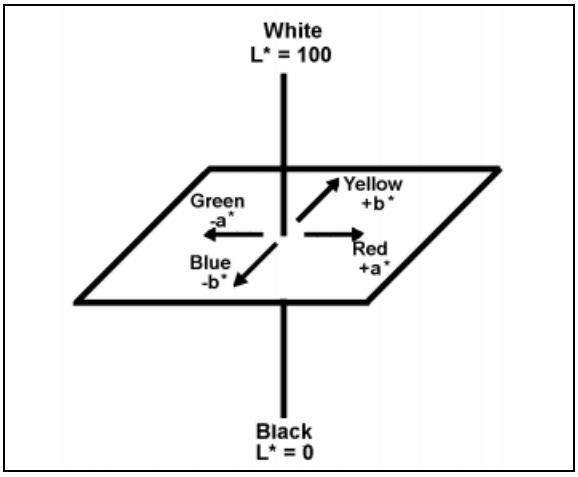


Fig. 1. CIELAB color space.

Fig. 1 shows CIELAB color space. The parameter $L$ represents lightness or darkness with $L = 100$ representing white and $L = 0$ representing black, positive a represents red, negative a represents green, positive $b$ represents yellow, and negative $b$ represents blue.

TABLE I: Colorimeter Data

| Exp | Dosage (g/mL) | Time (hr) | $L^*$ | $a^*$ | $b^*$ |
|---|---|---|---|---|---|
| 1 | 0.00 | - | 58.90 | 0.61 | -2.57 |
| 2 | 0.05 | 24 | 60.72 | 0.51 | 4.53 |
| 3 | 0.10 | 24 | 75.98 | 0.47 | 4.85 |
| 4 | 0.20 | 24 | 81.19 | 0.38 | 5.19 |
| 5 | 0.30 | 24 | 86.32 | 0.22 | 5.85 |
| 6 | 0.05 | 48 | 61.13 | 0.50 | 4.57 |
| 7 | 0.10 | 48 | 76.09 | 0.44 | 4.89 |
| 8 | 0.20 | 48 | 81.86 | 0.36 | 5.20 |
| 9 | 0.30 | 48 | 86.75 | 0.24 | 5.92 |

The data on color measurement is shown in Table I with manipulated dosage of AC (g/ml) and time contact 24 hr and 48 hr.

### B. Influence of AC Dosage

Experimental results indicated in Fig. 2 shows an increase in AC dosage increases color reduction. $L^*$ value were increase as increases dosage of adsorbent. It shows that color changes from darkness to lightness with maximum

decolorized $L^*$ at 86.75. Fig. 3 shows that color change ($\Delta E$) increases as dosage of AC added. Thus, decolorization prior to total placement of AC produced significantly greater $\Delta E$ than pacing none of AC.

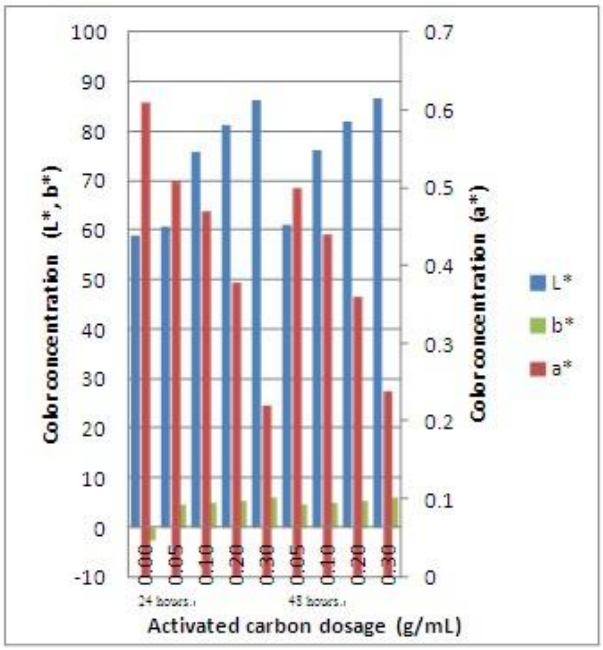


Fig. 2. Effect of different adsorbents dosage and contact time on decolorization of carrageenan gel solution.

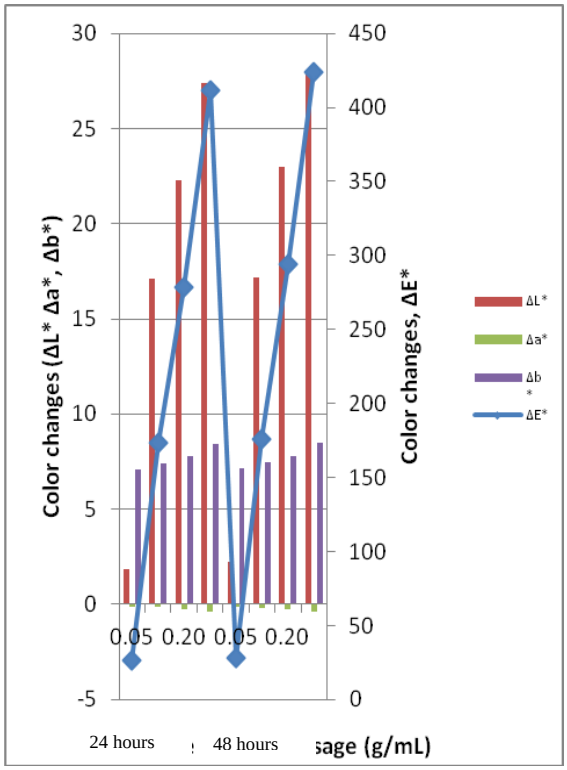


Fig. 3. Mean color changes from non-bleached to bleached carrageenan gel solution.

### C. Influence of Contact Time

Based on Fig. 2 shows that influence of contact time with decolorization of low molecular compounds. In some cases, with increasing time, color rises around 0.20 to 0.40 units. However, the changes are very small. Furthermore, it was mentioned that the duration of bleaching is responsible for the problem of color reversion [21]. Hence 24 hours seems better than 48 hours.

### D. Molecular Compound Analysis

The carrageenan solution before and after the activated carbon solution was analysed using UV-VIS Spectrophotometry. This analysis only to investigate effect of adsorption color for the sample, not on measure or to identify molecular compound in carrageenan.

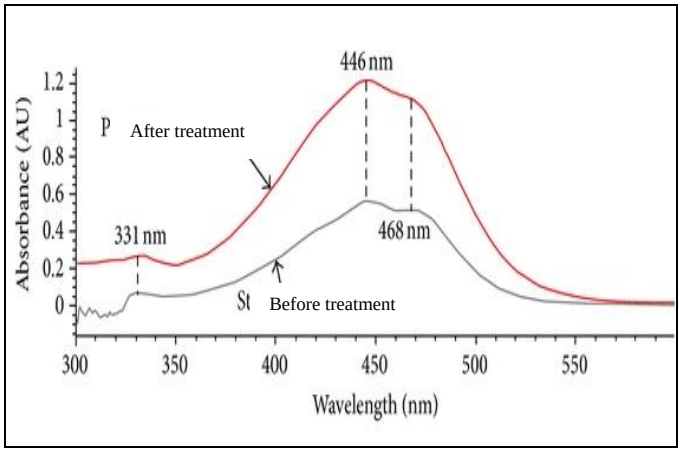


Fig. 4. Molecular compound of seaweed before and after treatment with activated carbon.

In this regard, the UV-visible spectrum of the treated compound (added with activated carbon) was recorded and its absorption maximum ($\lambda_{max}$) was compared with the untreated sample. Results can be seen from Fig. 4 that both the treated and untreated sample exhibited the same spectroscopic profile with similar $\lambda_{max}$ (331, 446, and 468nm). This clearly shows that there is adsorption process occurs. It is believe that the absorbent have an impact on the adsorption of color in sample. The color of sample becomes brighter by addition of AC.

## IV. Conclusion

Within in the limitation of this study, it can be concluded that the highest color change was produced by AC dosage at 0.3 g/mL. The least change was produced by contact time at 24 hours and dosage of AC at 0.05 g/mL. There were no significant difference in the color change (ΔE) produced with respect to contact time. Absorbance value for treated sample (at 24 hours and 0.05 g/mL) increased when compared with untreated sample. Hence, AC is a good decolourizing agent used to adsorb the color and odor of seaweed sample.

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