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Analysis of adsorption by eggshell membrane

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Abstract

This paper is aimed at analyzing how eggshell membranes adsorb substances in the water and revealing the mechanism of its adsorption.

The meaning of `adsorb` is a structure like a web which holds molecules of ink, so it is different from `absorb`.

The word `ABS` means absorbance, the amount of light which a material absorbs.

Eggshell membranes have typically been thrown away but it has a specific feature ; a great amount of mesh like structures.

This pattern is common among materials that adsorptions such as activated charcoal or silica gel.

Therefore, eggshell membranes are thought to be able to adsorb substances.

We conducted an experiment.

We soaked eggshell membranes into a solution of ink, and after at a designated time removed the membranes and measured the concentration.

Based on the results, we made a graph of the fluctuation of the solution.

The results show that the speed of adsorption rapidly decreased as eggshell membranes adsorbed solute.

It is argued the adsorbed solute filled the mesh and prevented other solutes from being adsorbed.

It is concluded the speed of adsorption depends on how many empty meshes remain.

1.Introduction

We often eat eggs and eggshells are utilized as fertilizer for soil.

However, eggshell membranes are inedible and usually discarded.

According to the preceding research, the eggshell membranes have structure like a web and it adsorbs materials.

So it is different from `absorb`.

Therefore they can be utilized as filters which adsorb harmful materials.

Without experimentation, it isn't possible to tell how the eggshell membranes adsorbs materials or how much materials are adsorbed and what kinds of materials are suitable to be adsorbed.

Therefore, we decided to examine the nature of eggshell membranes to promote using them as filters.

We expect the reason why eggshell membranes adsorb materials is the same as activated charcoal.

It adsorbs materials because of Van Der Waals force; called physisorption.

The materials are adsorbed in the micro webs which make up the eggshell membrane.

On the other hand, there are other forces that adsorb.

For instance, the static electric force, chemical force and so on.

Therefore, we conducted research on how eggshell membranes adsorb materials.

To research, we put eggshell membranes into a solution.

We exchanged solutions with other ones to examine what materials are suitable to be adsorbed by them.
At first, we used red ink as a solution because it is easy to measure the value of concentration of that solution.

2.Method

Red ink solution with a volume ratio of 1000:1 between distilled water and red ink stock solution was prepared. The main component of the ink was naphthalene di sulfonic acid. The eggshell with membrane intact is put in 50ml of the solution.

2-0 Preliminary experiment

Preliminary experiment was conducted to analyze whether or not boiling eggs and eggshell itself influence the adsorbing ability. The mass of the eggshell membrane with eggshell was 6.5g and the boiled eggshell membrane itself was 0.20g. They were checked a day after.

2-1.Experiment A

Experiment A was conducted to analyze the relationship between the length of time the eggshell membrane soaked in the ink solution and the adsorption capacity of the eggshell membrane. The mass of the eggshell membrane was 6.5g. The membrane was checked every 30 minutes for the first 7 hours then once at 16, 21, and 24 hours.

2-2.Experiment B

Experiment B was conducted to analyze the relationship between the amount of eggshell membrane and the adsorption capacity of eggshell membrane. It was soaked for 48 hours. We changed the amount of eggshell membranes like the following: 1.0g, 2.0g, 3.0g, 4.0g, 8.0g, 10.0g, 15.0g, and 20.0g.

To examine the amount of solute adsorbed by the eggshell membrane, the color intensity of the solution before and after the eggshell membrane was measured and quantified as adsorption by using a spectrophotometer(SHIMADZU UVmini-1240).(Experiment A and B)

2-3.Experiment C

In this experiment, 6.5g of the eggshell membrane, which was first soaked in an ink solution for 48 hours, then was soaked in distilled water for 72 hours to analyze the mechanism of adsorption.

3.Hypothesis

3-0 Preliminary experiment

If we boiled the eggshell membrane, it would be damaged and the adsorbing ability would decline.

The eggshell has almost no capacity to adsorb materials and doesn't influence adsorbing.

3-1.Experiment A

We expected that the more time a membrane would spend adsorbing solute, the more solute would be adsorbed. We also expected that the speed of adsorption will decelerate.

3-2.Experiment B

The surface area of an eggshell membrane is determined by the amount of it, so it is considered that the amount of adsorption will increase proportionally to the amount of eggshell membrane.

3-3.Experiment C

We expected an eggshell membrane would not discharge the molecules if it had adsorbed the molecule once.

4.Results

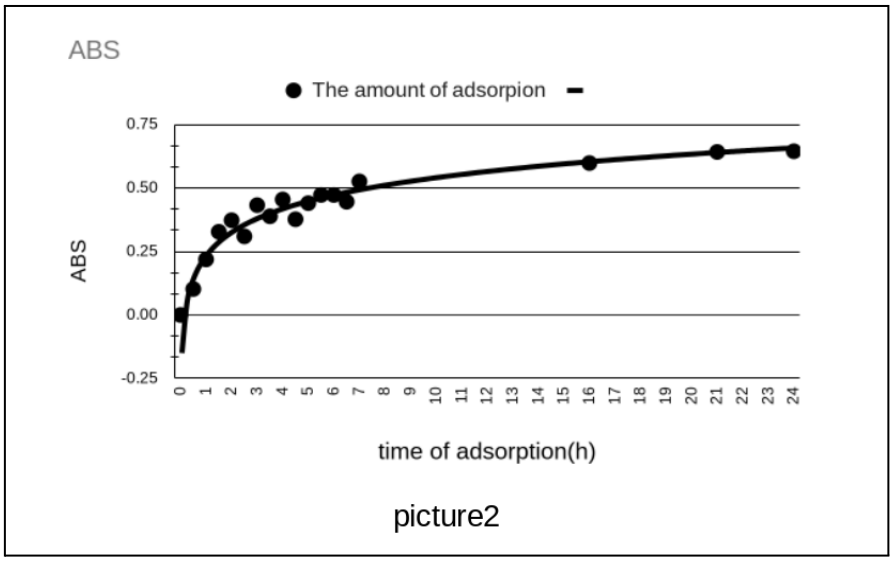
4-0 Preliminary experiment

The maximum amount of ABS after we put in only the eggshell membrane was 1.186.

On the other hand, the maximum amount of ABS after we put in boiled eggshell membranes with eggshells was 1.149.

The difference of the amount of ABS between the two solutions was 0.037 and the comparison of the amount of ABS shows no significant differences between the two solutions.

4-1.Experiment A



picture2

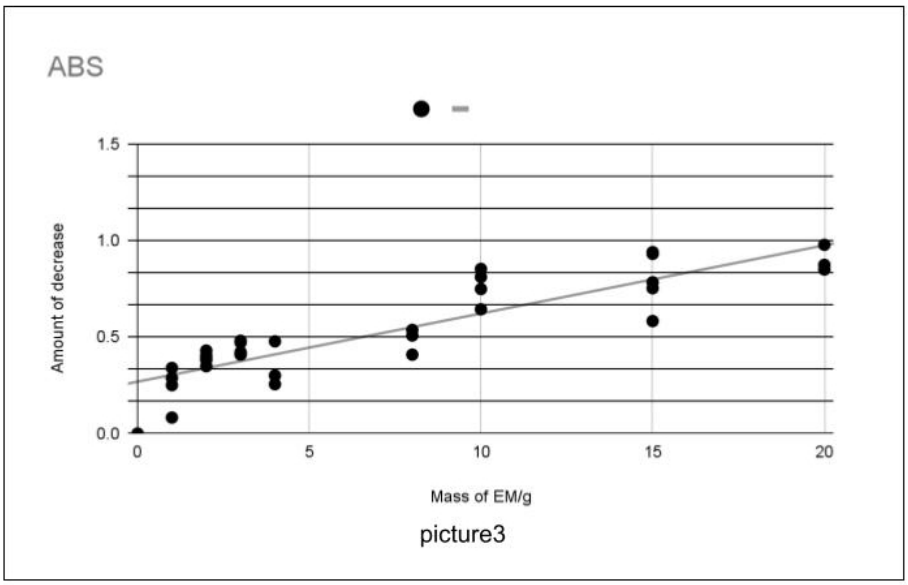
We plotted the ABS of light whose wavelength is within 515.0 nm ~ 516.5nm. The Y-axis of the above graph shows a decrease of the amount of ABS or the amount of adsorbed molecules.

The longer time we immersed the eggshell membrane in the solution, the more solute adsorbed.

On the other hand, the amount of ABS after 24 hours was more than half of the amount of ABS before we immersed the eggshell membranes.

The amount which is plotted on the graph shows the averages of each amount of ABS after the experiments.

4-2.Experiment B



picture3

We found a positive correlation between the amount of eggshell membrane and the decrease of ABS. However, the concrete relationship is not clear because the figures varied widely. When we soaked eggshell membranes more than 10.0 g, some values of ABS decreased to less than half through the experiment.

4-3.Experiment C

Some molecules of ink were released from the eggshell membrane, and spread into the distilled water. We measured the ABS by a spectrophotometer, and values we got were 0.315 and 0.414.

5.Consideration

5-0. Preliminary Experiment

Eggshells adsorb little solute of Naphthalene sulfonic acid. Therefore, we considered that the eggshell itself has little influence on the experiment and if we soak eggshell membranes with the eggshells, the result of the experiment won't change.

5-1.Experiment A

The curvature of the graph (picture2) represents the speed of adsorption. The speed was highest just after we started the experiment, but after 1~3 hours, the speed declined rapidly. By looking at the graph, adsorption seems to have nearly stopped at 24 hours after we started the experiment.

We considered that holes, which are as small as molecules of ink, got filled with them, the number of empty holes declined, and the membrane lost the capacity to adsorb.

As the number of empty holes declined ,the probability that a molecule would hit them decreased. As the adsorption progressed, the number of molecules which collided with the eggshell membrane declined. These seem to have caused a decrease in adsorbing speed.

We thought that we used too much ink because the eggshell membrane absorbed only part of the ink solution.

5-2.Experiment B

It is supported that the amount of eggshell membrane we soaked was too little for the amount of the solute in Experiment A by the result of Experiment B ; when we used the eggshell membrane with eggshells whose mass is more than 10g, the amount of ABS after the experiment reduced by less than half of what it was before the experiment. The amount of adsorbed solute increased slowly and it was not proportional to the amount of eggshell

membrane. In this experiment, the amount of ink was the same regardless of the amount of eggshell membrane used and differences in adsorption was difficult to detect. This difference might affect not only the speed of the adsorption but also the amount of solution that is adsorbed. We should use more ink solution so that the difference of the concentration after the experiments will decrease and be more detectable. We have to find a way to measure the amount of adsorbed solution directory.

5-3.Experiment C

By looking at the change of the ABS, it was clear that ink was released from the eggshell membrane. There are three kinds of adsorption: physisorption, chemisorption, and electrostatic adsorption. There are chemical bonds when chemisorption is made. Van der Waals bonds bind two objects together in physisorption. When two materials have different electric charge, static electricity binds them together - this is electrostatic adsorption. In this experiment, if there had been chemisorption, ink wouldn't have been released because chemical bonds are almost always irreversible. Also, eggshell membranes include the amino acids, glutamic acid and aspartic acid, which have a negative charge in the water. We thought that the main factors of the adsorptions were physisorption and electrostatic adsorption.

6.Additional experiment

We did several experiments with some kinds of other solutes to find the principle of the adsorption by the eggshell membrane .

6-1.Methylene blue

We used methylene blue as solute, because its purity was clear. The colloid particle of methylene blue has positive charge. It is suitable for measuring concentration by using a spectrophotometer because it has a vivid color.

6-2.Copper sulphate

The Naphthalene di sulfonic acid and Methylene blue are large molecules which have more than a 100 molecular weight. In contrast, copper sulfate solution, which contains copper ions, is a smaller adsorbent than these other solutes and whose concentration is expressed as a change in color strength. Therefore, we used it.

7.Method of additional experiment

Eggshell with eggshell membrane was added to 50 mL of methylene blue solution (0.01 g/L, ABS 1.614) and 50 mL of copper sulfate solution (0.1 mol/L, ABS 1.420) for 48 hours. The mass of the eggshell was 6.5 g. The ABS of both solutions were measured and compared.

Considering the possibility of reactions between the weakly acidic copper sulfate solution and eggshells composed mainly of calcium carbonate, 6.5 g of eggshells with eggshell membranes were placed in the same copper sulfate solution for 48 hours after the eggshell membranes were removed, and the ABS was measured and compared.

8.Result of additional experiment

8-1.Methylene blue

The ABS of the methylene blue solution decreased from 1.614 to 0.445 after the experiment.

8-2.Copper sulphate

The ABS of the methylene blue solution decreased from 1.420 to 1.369 after the experiment.

9.Additional experiment

Judging from 8-2 and 8-3, the ABS of the aqueous copper sulfate solutions after the experiment was 1.367 and 1.369, showing little difference.

In addition, we could find no visible evidence demonstrating the eggshells reacting with the aqueous copper sulfate solution such as gas formation. From these facts, it is considered that there was little or no reaction between the copper sulfate solution and calcium carbonate, that is the main component of eggshells, would have occurred. It is also considered that the eggshells do not interfere with the adsorption of the copper sulfate solution.

Judging from 8-1 and 8-2, the ABS of the methylene blue solution decreased from 1.614 to 0.445. The eggshell membrane adsorbed about 73% of the methylene blue in solution. When 20g of eggshell membrane was used in the experiment with naphthalene di sulfonic acid, the greatest decrease in ABS was observed, from 1.485 to 0.507. Since only about 65% of the eggshell membrane was adsorbed, taking into account the difference in the amount of eggshell membrane used it can be argued that methylene blue was more easily adsorbed.

On the other hand, the ABS of the copper sulfate solution only decreased from 1.420 to 1.367, which means that only about 3% of the copper sulfate in the solution was adsorbed. This fact suggests that copper sulfate is probably not a suitable substance for adsorption by eggshell membranes.

Methylene blue has a molecular weight of 319.85, which is almost as big as the molecular weight of naphthalene disulfonic acid, 280.3. Copper ions, on the other hand, has a formula weight of 63.5, which is the smallest tested adsorbent, even if it forms tetraaquacopper(II) ions in water. Since there is no extreme difference in the molecular weights of methylene blue and naphthalene disulfonic acid, it is assumed that the difference in the absorptivity of the two is due to their electric charges. In addition, both methylene blue and copper ions have positive charges. Therefore, we consider the difference in particle size was causing the difference in experimental results.

10. Future tasks

10-1 Experiment A-C

In this experiment, only the temperature and initial concentration of the solution were kept constant.

In the future, we will conduct experiments at different temperatures and solution concentrations.

We want to find an equation that can express the amount of adsorption and adsorption rate based on the relationship between each condition.

10-2 Additional experiment

Through experiments using solutes of different sizes, polarities, and charges, we will determine the mechanism of adsorption by the eggshell membrane and we will explore which adsorbates

are easily adsorbed.