Cargo Damage in Container Transportation and its Counter Measure for the NC Gels

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Abstract

An NC gel was synthesized as a countermeasure to cargo damage caused by container transportation. Clay that does not adversely affect the environment was used for cross-linking an agent to the NC gels.

I experimented with two kinds of clays, a Kunipia and a Sumecton. We prepared various kinds of NC gels. Samples were prepared using 10 kinds of concentration SA aqueous solutions. Many samples did not gelled, but a few samples gelled. It gelled only when the concentration of the SA aqueous solution using Sumecton was 1.20 and 1.25 wt%.

From these results, It was found that the possibility of using NC gel as a countermeasure sheet.

1. Introduction

We have been developing a reusable water absorbent sheet for quality control in container transport. We were able to confirm the usefulness of the poly N-isopropyl acrylamide (PNIPA) through the results of shortening the drying time of the sheet and the possibility of sheet creation[1・2]. The ion concentration changes in the gel and repetition characteristics of the water absorbent material are currently under study[3・4].

Phenomenon of condensation damage in the sea container transport is very problematic. Referring to previous cases, sweat damage has existed for a longtime before and even in recent years the number has not decrease. In 2011 there were 76 and in 2012 there were 166 cases[5]. These figures do not include defects in the containers and they were mainly from sudden changes in temperature.

Also moisture and changes temperature in the container are a major cause of condensation. In addition, the temperature differences can be up to 40 degrees or more when shipments travel from India to Hong Kong or from Hong Kong to Japan[6]. Fig.1 shows navigation map of one containership and the temperature of each port.

The average weight of a container included the floor materials, packaging and the cargo itself, usually to falling about 200 kg. The moisture in a container is about 10%, as 20 litters extra weight for each one.

Furthermore, the occurrence of condensation, according to a survey by the company, does not happen only during transport. Condensation has occurred even after arriving at the object of the harbor. A water absorbent sheet may be a countermeasure.

However, conventional sheets are problem in both environmental and cost because they were disposable. This laboratory researching has been re-usable water-absorbent sheets. For this research, in addition for cross-linking agent N-N, methylynebisacrylamide (BIS) is poisonous, also considering its impact on the environment, we aim to make water absorbing agent by using non-poisonous clay as a substitute for the cross-linking agent.

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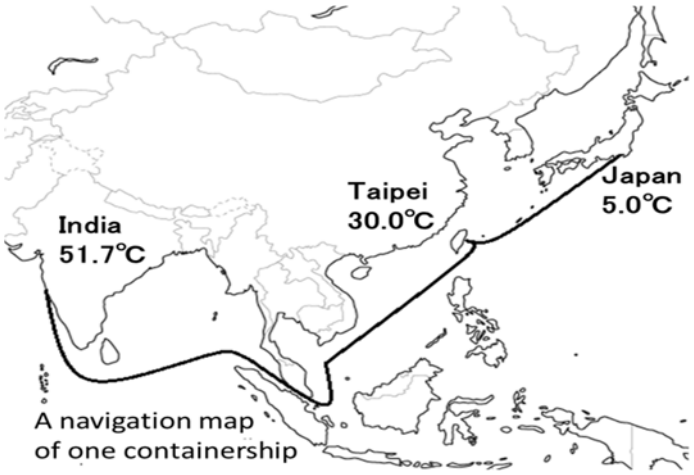

Fig.1 Navigation map of one containership and the temperature of each port[7].

2. Polymer gel and Clay

The definition of gel cannot be determined specifically because the gel itself has various different types. The nearest examples in our daily lives would be translated to agar, eggs or tofu and those are actually can be called gels[8]. There are other gels used as desiccants, and there are gels as contact lenses. Gels are used in various forms in daily life. However, we just do not realize those. In our body also includes gel which everyone does not know about. Gel is an important thing in our daily lives but we would only know it just for a little point of a big mountain. The application of gel is a reality but there are still undiscovered parts of it.

There are many forms of gel in our surroundings. This includes diapers, contact lenses and aroma products and in civil engineering there is shock absorbing material. We think while focusing on water absorption performance ability in gels, it would be water absorbent also so that it can be manifested in engine rooms in ships.

Clay has various functions in construction, pottery and industries. Clay is defined as an inorganic mineral. It can be processed or purified according to their use respectively[9].

In our research, we used the clay from Kunimine Industries which based on the clay called Bentonite. The characteristics of Bentonite which includes the ability to swell up over 10 times when absorbing water and give no negative impact to the environment. For this reason, it would be a possible source in making an environmental friendly reusable water absorbing sheet.

Kunipia is purified bentonite which the characteristics of bentonite mostly remains. Sumecton is a synthetic organic polymer with a Saponite structure. It is said that only Kunimine Industries synthesizes and manufactures Saponite. Both of these types of clay is used in our research. It's shown in the Fig.2. The relationship between bentonite, smectite and saponite is shown in the Fig.3. Both of them are montmorillonite as the main component, but there are differences in other components.

In recent research, soft material experiments using clay are topics[10]. It is an experiment that polymer gel was made by dispersing layered clay in Sodium polyacrylate so that molecules could be crosslinked[11]. An interesting point of this experiment is that more than 95% of the material is made of water. It turned out that using this clay successfully makes it possible to make new materials without adversely affecting the environment. The development of materials using clay and polymer structures has the possibility to be applied in various fields. Therefore, we conducted experiments to combine gel and clay so far.

Fig.2 Kunipia and Smecton

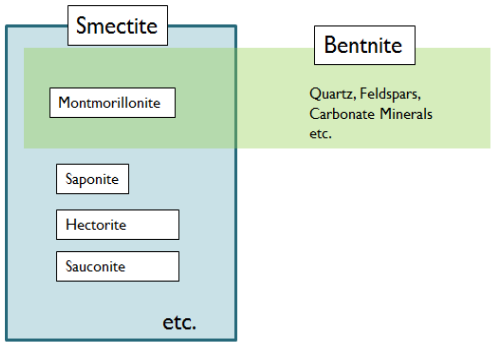

Fig.3 Relationship between Bentonite, Smectite and Saponite

3. Experiment

3. 1 Preparation of gel

10 Types of 50ml Sodium Acrylate solution (0.50, 0.80, 1.00, 1.10, 1.15, 1.20, 1.25, 1.30, 1.40, 1.50 [wt%]) is prepared and 1 g from two types of clay which is Kunipia and Sumecton is dissolved for each solution. Then, 3.88 g of N-isopropylacrylamide monomer (NIPA) is dissolved. After that, 120 µl of N, N, N', N'- tetramethylethylenediamine (TEMED) as polymerization accelerant and 0.02 g of Ammonium Persulfate (AP) as initiator is added before to be left in incubator on 20 ℃ for 24 hours for gelling.

3. 2 Experiment methods

Gels that are previously made contain BIS as cross-linking agent which is replaced with clay in this experiment. As BIS is present we think that the concentration of SA solution is unrelated to the process of gelling. So, we are investigating on how will gelling occur when BIS is absent. Starting from the normal amount that is commonly used, we think that SA as ionizer is inadequate and decided to increase the concentration gradually. The results are shown in the Table 1 and 2 along with the weight ratio of NIPA on 1g of SA. Fig.4 shows the preparation of the sample.

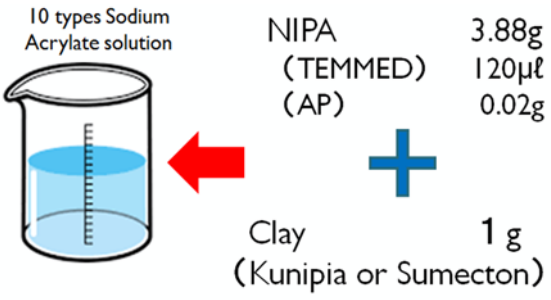

Fig.4 Sample preparation image

4. Results and discussion

4. 1 Results of Kunipia

The production of gel for this research is made by replacing BIS with clay as a cross-linking agent. We used Kunipia and Sumecton based on gelling ability from previous research made. We tested

gelling of clay on every concentration of SA solution because we do not know on which would make gelling occur. The concentration of NIPA as main chain, TEMED as accelerant and AP as initiator remains the same.

The experiment results for Kunipia on every concentration of SA tested is as shown in Table 1. From here, we concluded that Kunipia could not gel in SA solution. It was shown in the Fig.5.

As previously Kunipia was able to gel in the presence of BIS, we think it would be possible for it to cross-link NIPA as a replacement. However, the experiment results show that gelling is not possible for Kunipia as a cross-linking agent even when concentration of SA solution is in its highest and lowest possible.

Table 1 Experiment results of Kunipia

SA Concentration [wt%]	Gelling
0.5(NIPA15.52:SA1)	×
0.8(NIPA9.70:SA1)	×
1(NIPA7.76:SA1)	×
1.1(NIPA7.05:SA1)	×
1.15(NIPA6.75:SA1)	×
1.2(NIPA6.47:SA1)	×
1.25(NIPA6.21:SA1)	×
1.3(NIPA5.97:SA1)	×
1.4(NIPA5.54:SA1)	×
1.5(NIPA5.17:SA1)	×

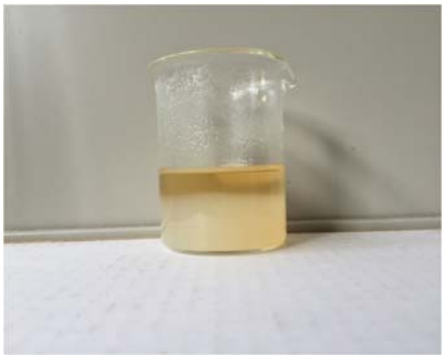

Fig.5 Experiment sample of Kunipia

4. 2 Results of Sumecton

The experiment result for each concentration of SA solution by using Sumecton is as shown in table 2. Fig.6 shows a sample with concentration of SA aqueous solution was 1.20 wt%. From here, gelling occurs in two types of concentration.

Sumecton is also expected to be a cross-linking agent for main chain NIPA. In this experiment, the highest and lowest possible concentration of SA is tested until gelling of Sumecton occurs when we found that gelling occurs on the concentration of SA solution on 1.20 wt%, another confirmation test is conducted on the same concentration and on the range of 0.05 around which is 1.15 wt% and 1.20 wt%.

Table2 Experiment results of Sumecton

SA Concentration [wt%]	Gelling
0.5(NIPA15.52:SA1)	×
0.8(NIPA9.70:SA1)	×
1(NIPA7.76:SA1)	×
1.1(NIPA7.05:SA1)	×
1.15(NIPA6.75:SA1)	×
1.2(NIPA6.47:SA1)	○
1.25(NIPA6.21:SA1)	○
1.3(NIPA5.97:SA1)	×
1.4(NIPA5.54:SA1)	×
1.5(NIPA5.17:SA1)	×

Fig.6 Experiment sample of Sumecton

4. 3 Discussion

From this experiment we found that gelling only occurs in Sumecton type of clay by dissolving in 1.15 or 1.20 [wt%] of SA solution. Apart from that, other concentrations of Sumecton were unable to gel and in Kunipia, all concentration of test piece were unable to gel and remains liquid or sol state.

Clay particles are separated and PNIPA are cross linked because SA in the form of solution separate clay by electric charge. However, we think that the ability to gelling depends on the type of clay and the concentration of SA. We illustrated image of clay cross-linking PNIPA in Fig.7.

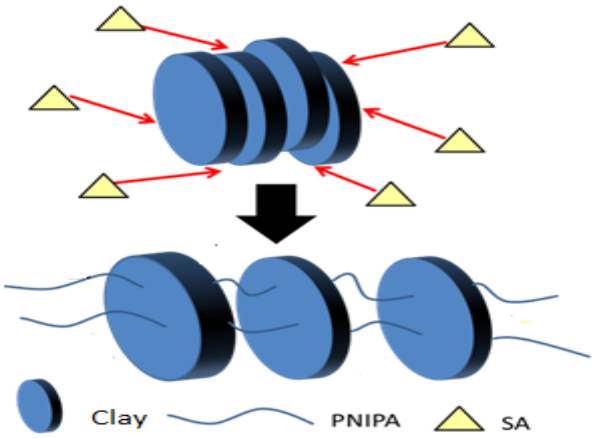

Fig.7 Image of clay cross-linking PNIPA

5. Conclusions

By considering its impact on the environment, BIS can also be replaced with clay. Clay has the properties to cross-link PNIPA to form gel. However, in order for SA to separate clay by electric charge, an adequate amount of concentration is needed and only certain types of clay can be applied. Other types of clay such as Kunipia may not cross-link with under these conditions.

Finally, it was found possible to use NC gel as a countermeasure sheet. In order to be able to adopt this gel in the development of reusable water absorbent sheets, more detailed experiments are necessary. In addition to its scientific importance, an understanding of the gelling of using clay will hasten the application of gel technology to the countermeasure sheets.

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