

## **Introduction**

It is difficult to go through a whole day without coming in contact with foaming materials. The soap and tooth paste that we use in the morning and before sleep, the foamed polyurethane seat cushion of the sofa or car seat, or the foamed polystyrene take away boxes that fill our foods in the restaurants.

In above case, foams are desired to achieve the finishing or result that we needed. However for paint manufacturers and applicants, in order to ensure a smooth and even final paint film, foaming will be one of the main task to overcome especially for those paints that are applied by brush and roller.

Thus additives like defoamer are needed to prevent the formation of bubble when liquid paint are subjected to external mechanical disturbance during application and production.

## **Foam**

In general term, foam can be defined as dispersing of gas (normally air) in liquid. It can be generated during production of a coating like in grinding phase, mixing and filling or during application. It also can be produced when liquid paint wetted porous surface like wood substrate. As a paint formulator, foams that are generated during application and porous surface wetting process are the problem that he or she wanted to solve.

Not all foams are the same. Some are transit type like the bubbles in Champaign and some are stubborn type like the foam in shaving cream depending on the viscosity of the medium and the surfactants involved.

## **Foaming or Defoaming???**

Foams are always been generated if a disturbance force apply to a liquid. The question is how long the lifetime of that generated foam is. There are many factor involved in term of physically and chemically to determine the stability of the bubble.

## **Theoretically Approach**

The stabilization of a bubble is depending on the elasticity of their thin liquid membrane. Thus higher the elasticity will result in more stable bubble and via versa. In order for us to understand more on the importance of this factor, let us look at Gibbs elasticity parameter that shows as below.

### **Diagram 1: Gibbs Equation On Elasticity.**

$$E = 2A \frac{d\gamma}{dA}$$

**E = Elasticity Parameter**  
**A = Bubble Surface Area**  
 **$\gamma$  = Liquid Surface Tension**

**Diagram 1: Gibbs Equation On Elasticity.**

According to Gibbs Equation, in order for a bubble to obtain some elasticity, the surface tension of the liquid has to change accordingly with the surface area of the bubble so that the values of  $d\gamma/dA$  will always more than zero. Any single foam that fails to change it surfaces tension during the contraction and expansion of the bubble will lead to bubble bursting due to high rigidity.

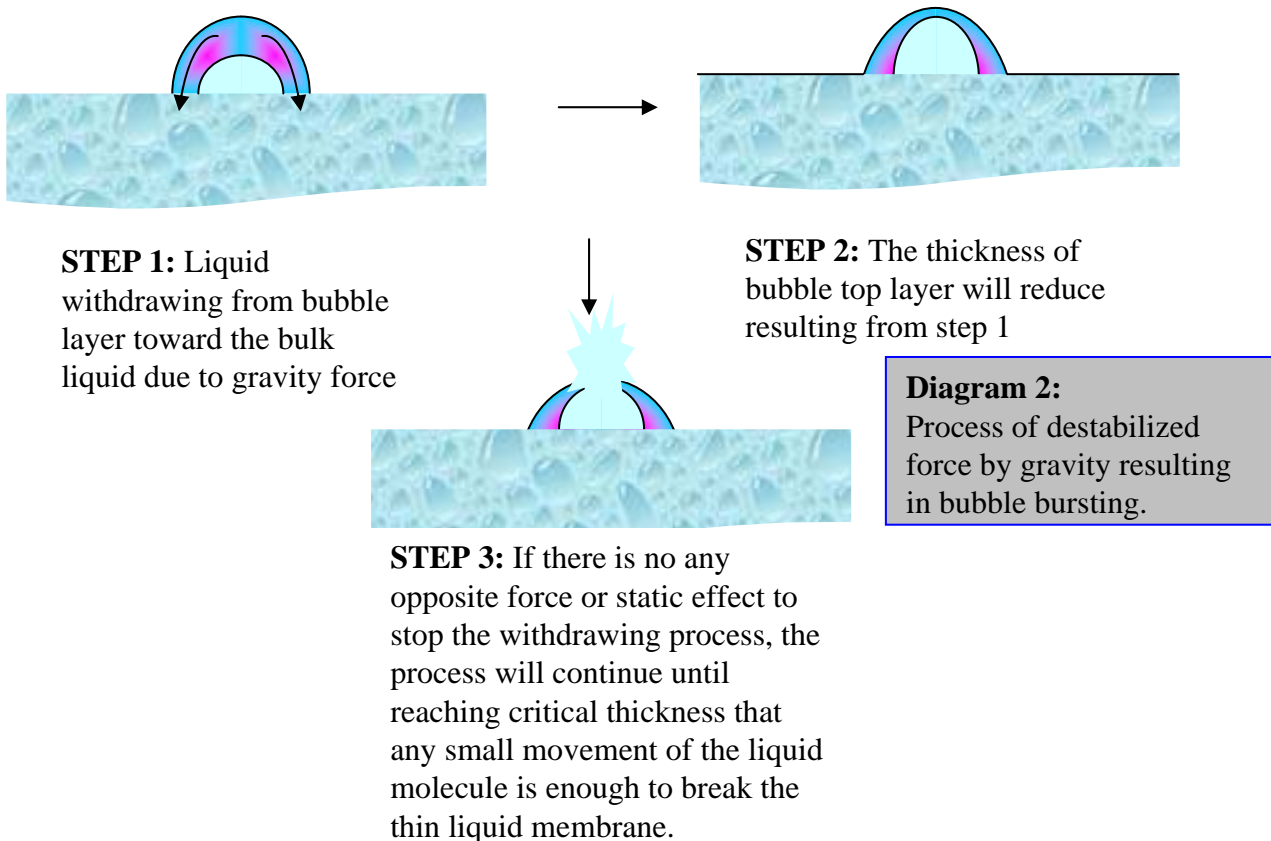
Pure liquid has almost the same surface tension all around the surface and it will almost stay as it was in any situation as long as no second material been added or changing it physical status from liquid phase to gas or solid phase. Thus, Gibbs Elasticity equation illustrated to us that pure liquid is not able to stable any foam.

Unfortunately in most of our coating formulations, there is no single formulation that involved only pure single liquid with same molecular structure and same molecular weight. Thus we still need to deal with this problem contently.

## **Destabilize Foam Factor**

### **Gravity Force**

When foam is form, due to gravity the liquid on the bubble layer will withdraw from bubble layer towards the bulk liquid. When the thickness reach it critical thickness which is nearly  $100\text{\AA}$ , a simple movement of molecule on that thin layer will result in bursting of that bubble. This process take place very fast within a few second. Further illustration show in diagram 2.



The above explanation supporting the equation of Gibbs as illustrated previously. Thus no pure liquids are able to stabilize any foam if they have been separated alone.

## **Stabilize Foam Factors**

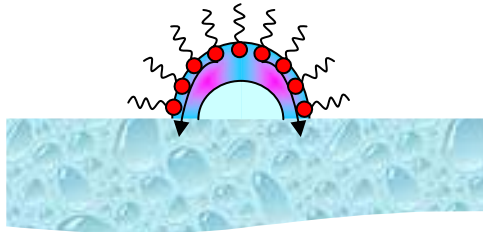
### **Marangoni Effect**

As we understand from previous explanation on how foams can be destroy. Thus, in order for bubble to be stabilized, a second material need to be added to ensure a more elastic bubble film. Most of the time a surfactant that can reduce the surface tension as well as very compatible with the system can serve the purpose.

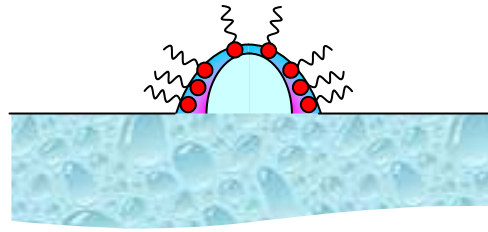
Marangoni effect will explain the effect of surfactant in stabilizing the bubble by using surface tension different that had been generated during the withdrawing of liquid from the bubble layer to the bulk liquid.

When a bubble is generate by an external shear force, the usual withdrawing process by gravity will took place immediatly. However due to the surfactant already been added, the withdrawing process will resulting more surfactants also been drain always together with the liquid from the top part of the bubble and also due to less space available and the bubble layer at the top is getting thinner. Therefore it created a situation were by the top part of the bubble would have higher surface tension than their other part.

As we learn that surface tension will flow from low surface tension area toward the high surface tension area and this will create another opposite force that causing re-flow process of the liquid back to the top part of the bubble will start to take place. When this two forces achieve an equilibrium before the critical thickness of the foam, than we will have a stabilized foam or bubble. The whole process is illustrated more in diagram 3.

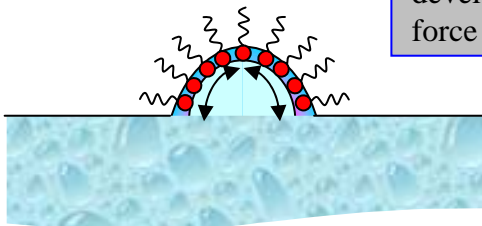


**STEP 1:** Liquid withdrawing from bubble layer toward the bulk liquid due to gravity force

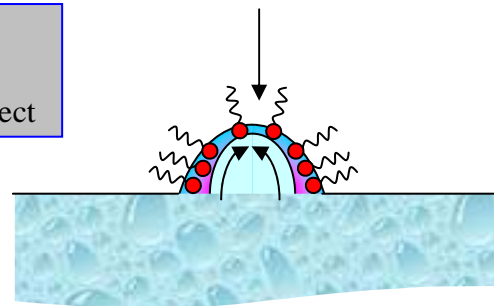


**STEP 2:** The effect of the withdrawing, the top part have less thickness than the side part and forcing less surfactant can be occupied on top.

**Diagram 3:** Process of developing stabilized force by Marangoni Effect



**STEP 4:** The withdrawing and re-flow forces will come to an equilibrium status and if it enough to achieve before the critical thickness, than we will have a stable bubble.

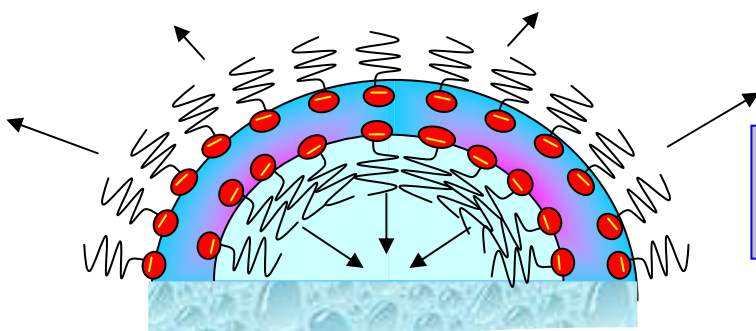


**STEP 3:** Surface tension gradient appear as top part have high surface tension that the side part. Thus opposite force created as low surface tension area will flow to high surface tension area. The liquid will begin to re-flow back to the top.

## 2) Static Effect

Most of the surfactant always carries a polar or electrical charge head and the hydrocarbon tail. In the bubble liquid layer, the surfactants will orient themselves as in diagram 4. Thus when the liquid withdrawing process started, it will bring the polar/charged head of the surfactants close to each other.

Therefore the same charge of those polar/charged head will start to repulse to each other. The direction of this repulsion forces are heading to the central of the bubble circle for those surfactant in the inner layer and creating an opposite force that heading to opposite direction of the bubble circle central. An equilibrium status will be achieved and resulting a static situation that stop further drainage of liquid to the bulk liquid. If the equilibrium bubble layer can achieved thicker than the critical thickness, stable foam have been created.



**Diagram 4:** Process of developing stabilized force by Static Effect

### Criteria's To Be A Defoamer

All Touch Chem defoamers are based on 2 main criteria's in order to ensure they will perform as what they have been designated. Both requirements are necessary to work together side by side to ensure a good performance.

The two basic requirements are as below.

1) A defoamer must have limited compatibility with the system and must able to do so after long term storage.

- A limit compatible will ensure the defoamer will be de-wetted by bubble layer liquid in order to destabilize the Marangoni and Static Effect. The de-wet process that take place will push away the liquid on the bubble layer and this will accelerate the drainage process that lead to bubble breaking. More explanation will be show in Diagram 5.

2) A defoamer must be able to reduce the surface tension of the system.

- In order for a defoamer to enter particular foam, they must be able to penetrate and evenly spread on the foam liquid layer. Thus a lower surface tension will ensure this will happen and it can be explain as below equation.

A positive value of Penetration Parameter,  $E$ , will ensure that a defoamer will go into the bubble liquid layer.

$$E = \gamma_l - \gamma_d - \gamma_{dl} > 0$$

where,  $\gamma_d$  = defoamer surface tension  
 $\gamma_l$  = liquid surface tension  
 $\gamma_{dl}$  = defoamer and liquid surface tension

A positive value of spreading parameter,  $S$ , that will ensure that a defoamer will evenly spread through the whole bubble.

$$S = \gamma_l - \gamma_d - \gamma_{dl} > 0$$

Thus the whole process can be illustrated as diagram 5 as below.

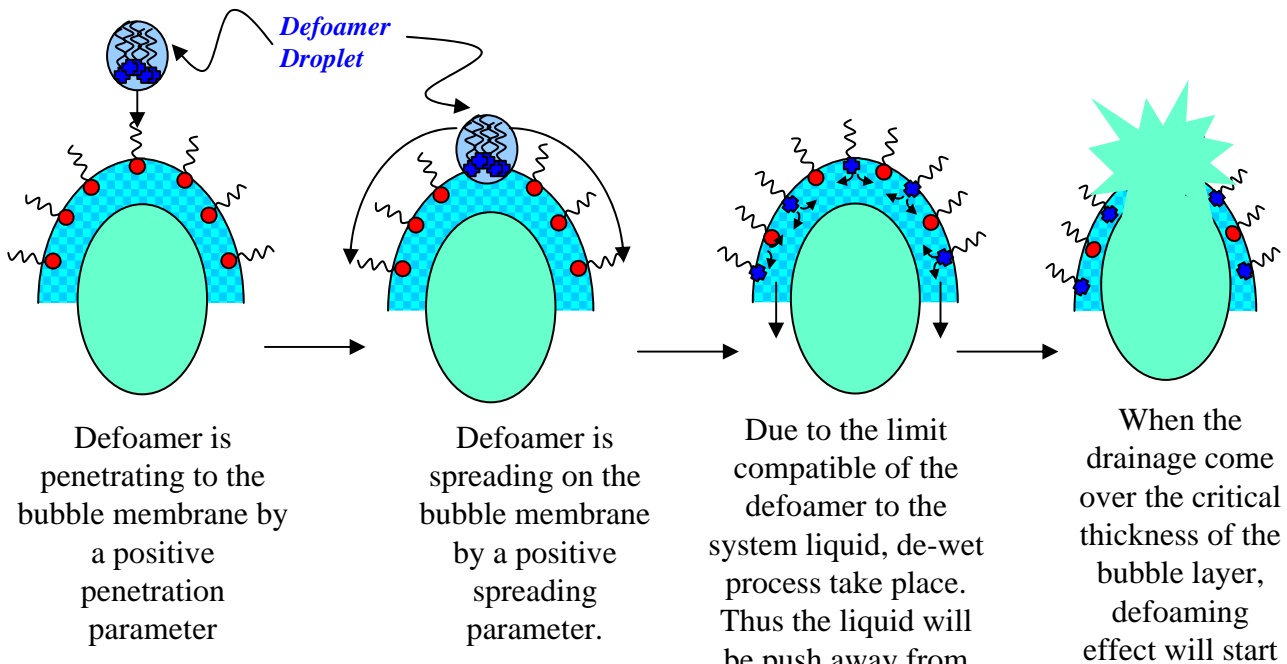
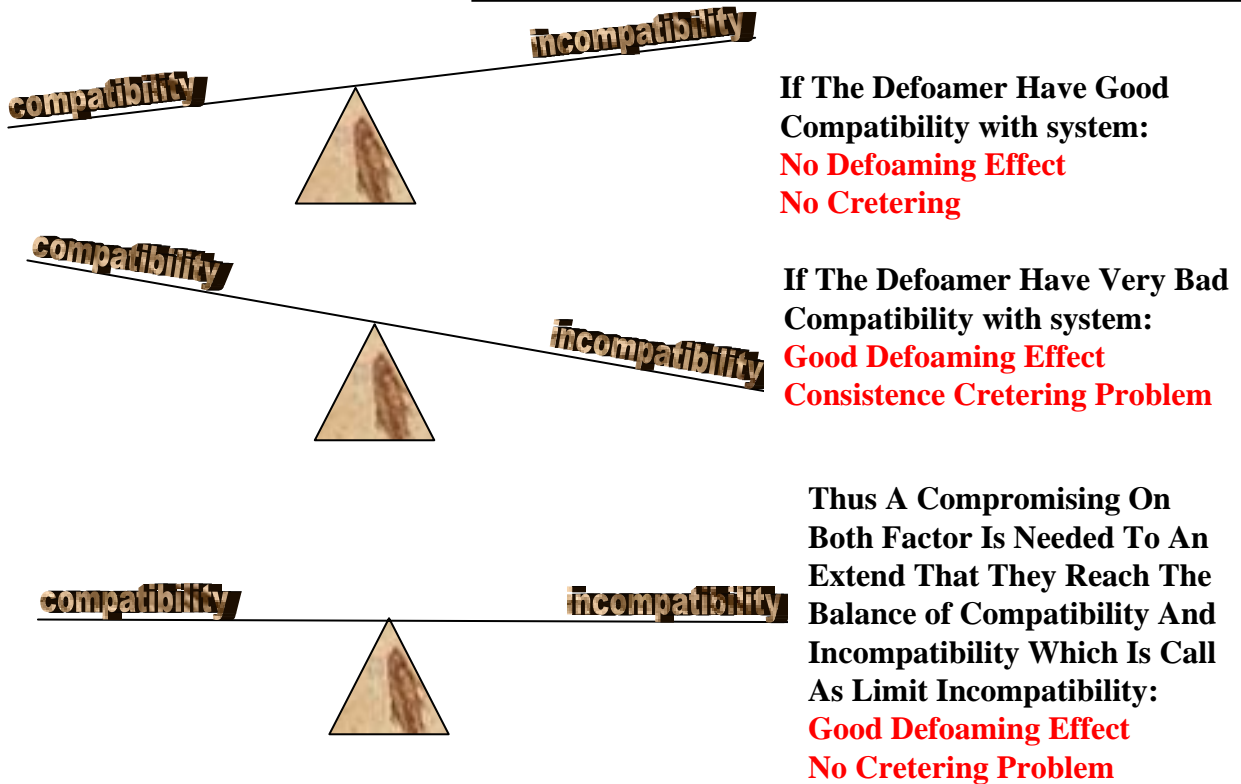


Diagram 5:  
Process of Touch DF Defoamer destabilized bubbles to achieve defoaming effect.

**Compromising In Using Defoamers**

Diagram 6: Showing the compatibility factor that influent the effectiveness and side effect of a defoamer.



As we had explained that one of the main factor to be a defoamer has to have some limit compatibility. Thus the compatibility or incompatibility of a defoamer with the system playing a main role in determines the effectiveness of a defoamer. However as we know that an incompatible material will also causing crater problem. Thus diagram 6 showing that we need to compromise on using a defoamer.

As defoamers that have good compatibility will in fact stabilize the foam and will not have any deforming effect at all, thus no tendency to crater. However this will not serve our purpose to solve the foam problem.

As defoamers are very incompatible with the system than have very good defoaming will be achieved but crater will be very easy to happen. This is also not desire for all the formulators. Thus sometime they needed high shear force to improve the incorporation in order to ensure all defoamers added are well disperse through out the system to avoid crater.

Thus, in general term, normally a defoamer that are more close to it compatibility with the system will have less defoaming effect than the one that have less.

### **Defoamer**

In today market for defoamers are mainly based on 2 chemical materials, high molecular weight Polysiloxane and Silicone free high molecular weight Polymers. As for Polysiloxane in chemical nature can give a better surface tension reduction than the non-silicone, thus it will give better incorporation due to better penetration and spreading factor as explained above.

However many paint chemist also fear of the intercoat adhesion that can be cause by silicone based material. As for our experience, in most of the cases, this is not true for Polysiloxane bases defoamers. In order for us to understand more, let us look at the molecular weight in relation on the viscosity that used for this purpose.

#### **FLOW CONTROL**

5-50 mPaS

#### **SLIP/LEVELING**

100 mPaS

#### **DEFOAMING**

5000-50000mPaS

#### **HAMMER FINISHES**

>50000 mPaS

Due to it very high molecular weight that compare to the grade in slip and leveling, it act as a heavy weigh polymer that can't really surface out to the surface of the finishing coating in order to disturb the overcoating problem.

Non-silicone polymer normally can't beat the surface tension reduction ability as the silicone but they have advantages on better limit compatibility than the Polysiloxane. Thus it will have better defoaming effect but less easy to be incorporated. Therefore higher sheer force need to be applied in order to ensure no crater obtained. However the easy incorporation factor still depending on the concentration of the solution supplier.

Some terminology that involve defoamers performance are explain as below:

1) Defoaming

Defoaming performance of a defoamer is determine on how fast a defoamer can destroy foam that created. Faster defoaming performance is desire by most paint formulators.

2) Deaeration

Deaeration is the process of moving the foam from the under layer of the paint to the surface of the liquid. Foam only can be destroy on the surface of the liquid and the faster deaeration property is desire by most formulator.

3) Anti-Foam

Anti-foam is referring to a defoamer that have the ability to prevent foam formation or suppress the bubble formation after the system has been agitated. Less foam formation after the agitation is a good anti-foam defoamer and this is also the most desire performance that most paint formulator wanted.

## Defoamer Testing Method

Defoamers need to be carefully selected to suit certain resin system. Thus the most direct method to choose a defoamer is by incorporate into the system and applied it to look at the desire effect. If the result is satisfying the purpose, than we will do further test on other properties test. The other tests are crater, gloss influent in final coating, on line test and so on in order to ensure that it can be use in the formulation. However if not than other defoamers have to be tested again.

However in here we recommend a method that we can make a good comparison between a few defoamers simultaneously. The purpose of this method is to ensure that we are getting the best defoamer as well as deaeration effect for a particular system. The test is also quit easy to carry out.

Requirements : Red Devil / TOUCH TC-0188 Shaker  
High Speed Mixer  
Glass Jars (100ml)  
Polyester Foil  
Applicators

### a) For Normal Solvent based system

#### Procedure

Fill the glass jars to a certain level (Not more than half) with the coating system + defoamers. Make sure that the level is almost the same. Mark the coating top level with a marker. Put the glass jars into the shaker. It also can be carry out by using a High Speed Mixer but make sure that the time and the speed are the same for each separate samples. However TOUCH TC-0188 shaker is more preferable as we need to compare those samples in accurate dispersing time and as well as same sheer force in order for us to judge more precisely the defoaming and deaeration properties.

#### Result

##### Observation

##### i) Defoaming effect comparison

Immediately after shaking or mixing, mark the increase foam level. Leave the glass jars for a side and record the foam level over 5 minutes, depending on how fast the foam disappear. Thus the lower the foam level will indicate the best defoamer among the samples that you have been tested. However sometime the resins is in low viscosity and immediately after shaking or mixing the foam level is not clear too judge. Thus we need to look at the tested samples on how much foam trapped on the surface and during the observation time which one will have less foam entrapment will be the best defoamer for this system.

##### ii) Deaeration effect comparison

Deaeration is the process of moving the foam from the bottom of the bottle to the surface of the liquid. Thus in order for us to judge the deaeration property, we look at the entrapment of the microfoam that still lay in between the bottom and the surface of the liquid. The less entrapment will have good deaeration. However you may observe that good deaerator did not mean will be a good defoamer.

##### iii) Anti-form effect comparison

Anti-foam is referring to a material that have the ability to prevent foam formation or suppress the bubble formation after the system has been agitated. Above testing is also able for us to see the anti-foam performance of a defoamers. Immediately after the shaking or mixing, observe the quantity of foam generated on the surface. The more foam generated will lead to less anti-foam performance. Thus a good anti-foam material will be able to prevent foam formation as much as possible after agitation.

##### iv) Site effect comparison

As mentioned early, defoamer will gives some site effect due to it incompatibility requirement to be an effective defoamers. Due to it low surface tension, in most of the time it will change the leveling performance of the system as well as creating cratering problem. To check the site effect as mentioned, apply the selected defoamer systems and apply it on Polyester sheet with an appropriate thickness of an applicator. Observe the leveling performance as well as crater formation.

#### Final Stage

A selected defoamers will need to go through the real application for final confirmation of the end performance.

b) For water based emulsion paint system

For water based emulsion, there is no simply way to pre-select a defoamer as descript in normal solvent based system above. The defoamer have to be effective in the pre-mix stage as well as in the final let down stage. Further more in the formulation of emulsion, it involve thickener that the rheology of the paint is rather higher. Thus in such conditions, full set real testing is needed, start from pre-mix, after mix and later real application by roller or brush on a big panel.

Water based defoamer for emulsion are normally recommended to divide the additional of defoamer in to 2 steps. 40-50% of the total amount require defoamer is needed in the pre-mix stage and the rest should be added in the let down stage. Most defoamers for emulsion paint, are not stable under high sheer force, it become more compatible to the system and can not performance the defoaming property any more. Thus it need to be added again in the let down stage in order to boost back the defoaming performance in the system.



Comparison test on Touch DF 4001 with competitor products

Objective : The test is to comparing the water based defoamer efficiency with current available competitors.

Apparatus and instrument

- 1)300ml glass bottles.
- 2)Lab Weighing scale, max 3200.00g.
- 3)Dropper to dose in the defoamer.
- 4)Shaker, Touch TS-0188.
- 5)Dispermat CV mixer

Sample and materials

- 1) Co-polymer latex
- 2) Water
- 3) AMP-95
- 4) Touch DF 4001 and competitor samples.

Procedure

Weight in co-polymer latex at 50.00gram and water at 30.00gram. Mix homogenously with mixer. Drop in AMP 95 until obtain the pH at 8.5 – 9.0. Drop in the defoamers at 0.20gram in each sample bottles.

Put all the samples into the shaker and shake for 10mins. Immediately after 10mins, open the cap and compare the foam level. Compare the foam level in each 3mins interval. Record the result.

Result

Comparison with competitor 1

Touch DF 4001

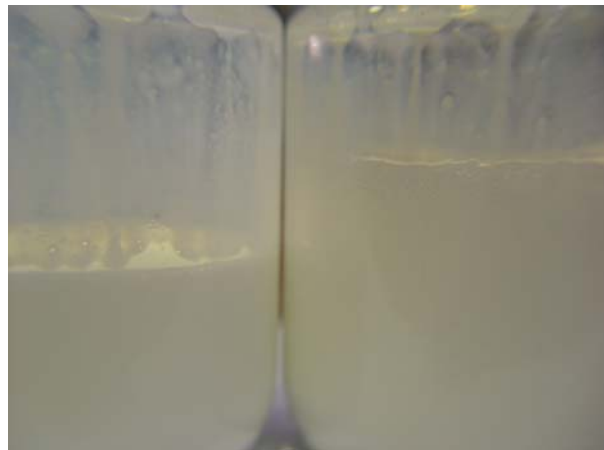
Competitor 1



Result after 10mins immediately after shaking

Touch DF 4001

Competitor 1



Result after 3mins

Touch DF 4001

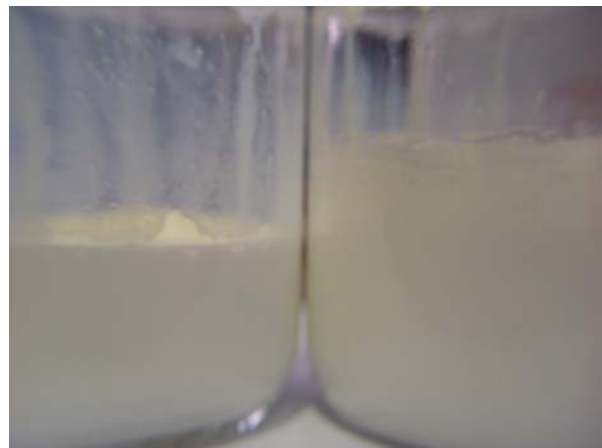
Competitor 1



Result after 6mins

Touch DF 4001

Competitor 1



Result after 9mins

Touch DF 4001



Competitor 1



Top view after 9mins

Comparison with competitor 2

Touch DF 4001

Competitor 2



Result immediately after shaking

Touch DF 4001

Competitor 2



Result after 3mins

Touch DF 4001

Competitor 2



Result after 6mins

Touch DF 4001

Competitor 2



Result after 9mins

Conclusion

As show in above result, Touch DF 4001 is better in term of defoaming comparing to competitor 1 and 2.

Note

Test of water based defoamer need to be carry out in high sheer force incorporation in order to make sure that all defoamers are fully incorporated as in real production it will also subjected to high sheer force dispersion stage.. By this way we can also observe the below properties:

1. Anti-foam
2. Defoaming
3. Defoaming properties against shear force. Most water based defoamer will lose it defoaming properties after subjected to high shear force. With this test, it will also indicate the long term storage efficiency of the defoamers in the paint as most water based defoamer will lose it defoaming properties after long time staying in the paint system.