Defoamer Comments in Regards to Water Based Tape Casting

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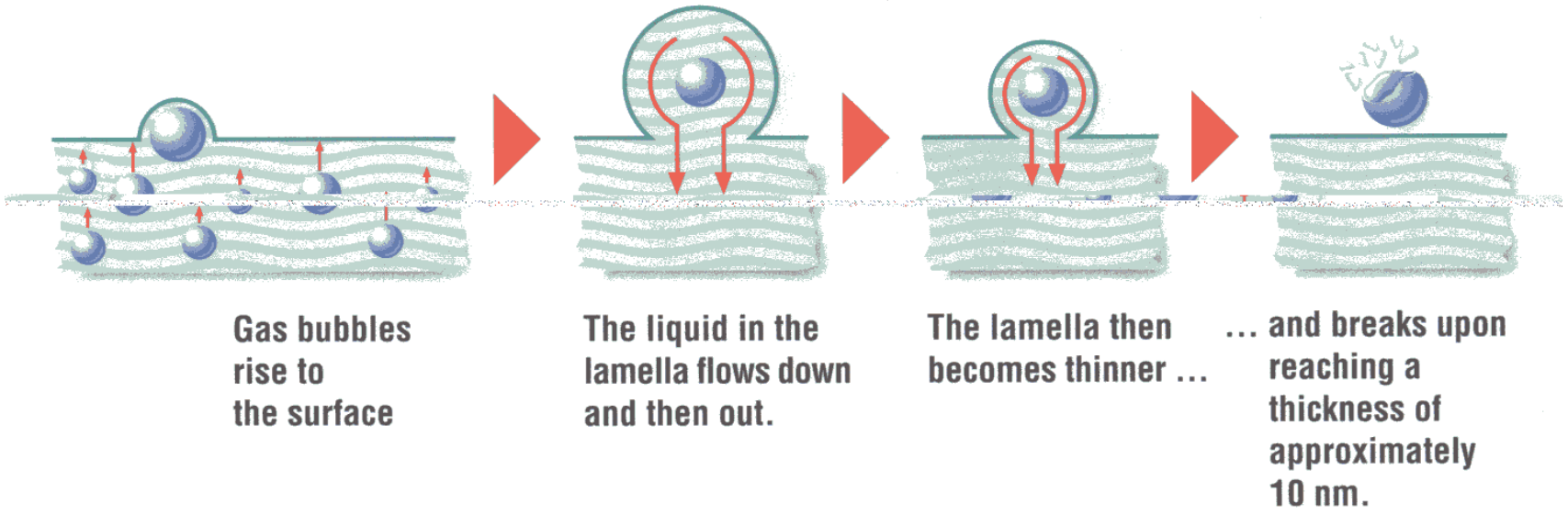
Introduction and Background

- Defoamers need to have low surface tension and some level of low incompatibility with the system they are used in to work effectively.
- The defoamer type and concentration is selected to give the proper balance between compatibility and foam control.
- A typical situation is as the incompatibility or concentration of defoamer is increased the foam is more effectively controlled but if the incompatibility or concentration is too great surface defects will result in thin cast tapes.
- Therefore the correct situation is to have reasonable foam control (there is typically some foam formed during ball milling but it will break if the slurry is allowed to sit undisturbed for ~15 minutes) without going to the point of generating tape defects (typically fish eyes/craters, orange peel or tiny gels).
- In years of PII evaluation of hundreds of defoaming systems no “Magic” defoamer has been found that will completely destroy all foam and not create defects at excessive levels.
- However, DF002 when used properly with WB4101 systems works very effectively in practical water based tape casting formulas and has a wide effective concentration window.
- DF002 if mixed with water will show a great incompatibility but when dispersed properly in a WB4101, water and ceramic system gives just the right level of incompatibility and foam control.

Introduction (con’t)

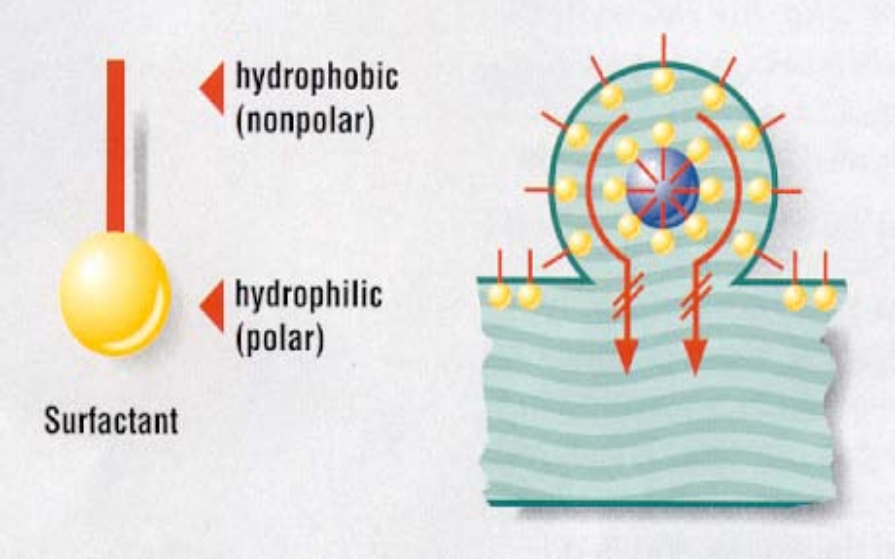
- Concentration of DF002 is usually not as critical as most defoamers due to its mild incompatibilty but there are some keys to its use.
- DF002 must be dispersed and have time to come to equilibrium with the system. This means it should not be simply hand mixed or stirred into slurry to destroy foam and then cast, as defects will result. It is important that the DF002 have at least some time (perhaps an hour or more) of intense mixing with the slurry during dispersion of ceramic (typically ball milling).
- DF002 incompatbility increases with increasing temperature and decreases with lower temperatures. So it is possible lower levels of DF002 are needed at high temperatures and more for low temperatures but of course the more practical way to deal with this is to keep the slurry making and slurry storage conditions at a reasonably constant room temperature.
- As milling continues the DF002 becomes less effective so for this reason in a two stage ball milling operation usually the total DF002 added is in two portions equally split between the two milling stages.

Foam



- Bubbles and foam are a high energy system and are not thermodynamically stable.
- Eventually the bubbles rise, their walls thin and the bubble breaks as shown above.
- However, in certain systems such as water systems with surface active materials present (such as slurry) there are stabilizing forces which help stabilize the foam and slow foam breaking as explained in the next slide.

Wetting Agents Can Stabilize Foam



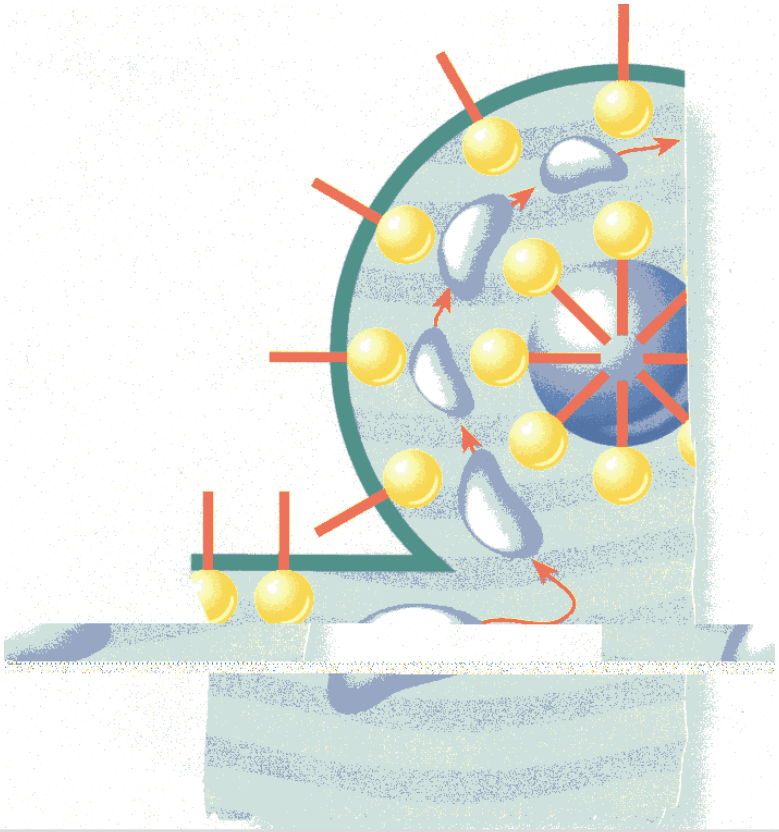
•Many dispersants and binder systems have molecules with both hydrophobic and hydrophilic portions. The hydrophobic portions (for example hydrophobic organic portions) want to get out of the water and yet the hydrophilic portions (such as ionic portions) want to be in the water.

•Since the hydrophobic and hydrophilic portions are attached to one another the molecules align at the interface of the air and water as shown above.

•In the case of a bubble there are two air to water interfaces (one inside the bubble and the other outside the bubble). Therefore the hydrophilic portions align and oppose each other in the wall of the bubble.

•Typically these hydrophilic portions have a like charge so repel each other keeping the wall of the bubble from thinning enough to break this stabilizing the foam.

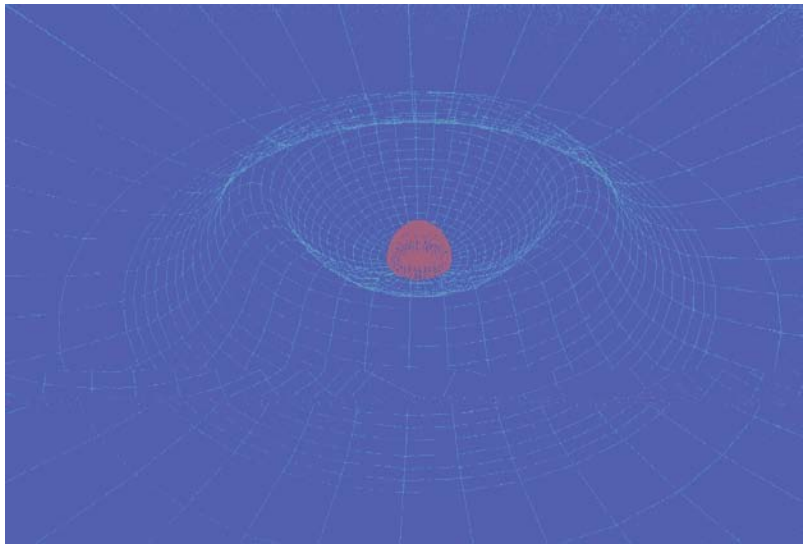
Defoamers Operation



- Defoamers work by limited compatibility and low surface tension
- Compatibility solution Vs film
- Balance foam Vs defects

•Most defoamers due to limited compatibility and low surface tension form small globules of a separate phase. Since this phase has a low surface tension when it contacts the surface of the liquid the defoamer will break and wet the surface of the liquid (since lower surface tension liquids will wet higher surface tension liquids).
•If there are enough of the defoamer small globules they can enter the bubble wall and disrupt the repelling forces and cause the bubble to break.

Craters or Fish Eyes



- Low Surface tension second phase.
  - Excess or too incompatible defoamer or wetting agent
- Contaminated particle

•However if the defoamer globules are too large due to too high of an incompatibilty (or higher temperature) , too high a concentration, or inadequate dispersion the larger globules with touch the surface the cast film and wet the surface causing material flow and disruption that will cause a crater or fish eye.

Defoamer Precautions

- Moderation and balance is the key
- High level or strong defoamer eliminates foam but can cause surface tension and incompatibility effects
  - Craters or fish eyes
  - Orange peel or flow problems
  - Pinholes (sometimes microscopic)

Defoamer/Wetting Agent Balance

- There is not yet any magic defoamer
  - Defoamers rely on controlled incompatibility
  - There must be balance between wetting agent and defoamer
  - Too much defoamer makes defects due to larger second phase of surface active agent
  - Too much wetting agent makes too much foam

Ceramic Differences

- Defoamer balance effected by type and amount of ceramic.
- Effected by other dispersants and other additives.
- Strong additive interaction possible due to high surface tension agents.

Normal Foam Behavior

- A layer of visible foam after milling is normal but if the ball mill is opened and foam is coming out the top or near the top more defoamer is needed.
- Normally the foam should break if the slurry is allowed to sit for perhaps 15 minutes undisturbed.
- Final removal of foam before casting:
  - Slow rolling (less than 5 rpm)
  - Let slurry sit for several hours
  - Vacuum defoaming (usually needed in high viscosity slurries for casting thicker than about 100 microns).
  - Care should be exercised during pouring, filtering or other processing to not reintroduce foam