Casein Glue

Lady Samin

Note: Casein glue is an excellent glue to use when assembling paintbrushes. The resulting bond is strong and will not come apart when the brush gets wet in use and cleaning.

How I make cheese glue, and the science behind it:

Materials:

- 1 Pint of non-fat **raw** milk – highly pasteurized milk does not work well, due to the heat it experiences.
- ¼ cup vinegar
- Teaspoon of pickling lime
- Lots of water
- 1 cup or container of some kind
- 1 Teaspoon
- Large basin or bucket
- A board about 1' by 1.5 '
- Another bit of board about 4" square
- Towels

Process:

1. Put a pint of raw skim milk into a bowel. Add about a quarter of cup of vinegar, a little at a time, and mix well, until the milk separates. Add less or more vinegar, if needed.

   Cow's milk contains 4.4% fat, 3.8% protein, and 4.9% lactose. At the normal pH of milk 6.3 - 6.6, the protein remains dispersed evenly in the solution. Only the protein, casein, is needed for the glue. Since only the protein is needed, it is easiest to start with raw low-fat milk.

   To isolate the protein, the pH must be lowered. A mild acid is added, vinegar will work well, but almost any mild acid would work. This reduced the pH to around 4.6 and allows the curds and whey to separate. The curds (protein) coagulate into a mass, and the whey is the white liquid.

   About 85% to 90% of casein in bovine milk is in a porous, spherical aggregate called a casein micelle, which floats freely in the milk solution (Guo & Wang, 2016) . When acid is added, these coagulate into large clumps of micelles, (called casein plastic in this diagram). The added H+ ions bind the smaller micelles into much larger ones, which then fall to the bottom of the mixture as a solid, we call curds. The remaining liquid is the whey.

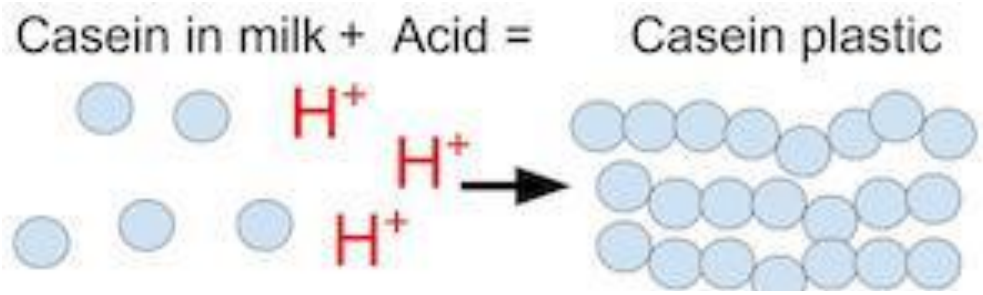

Figure I Image from Study.com

2. **The above can be skipped by using any low-fat cheese. A hard cheese would need to be soaked in water for several days to soften it up, so low fat mozzarella works very well – it's already soft. Just break it up into little pieces and put it into the warm water and follow the steps below. Note: too much (105 degrees F or above) heat allows the protein to break down into its amino acid components, and the glue will not work (therefore pasteurized milk will not work).**

3. The cheese is broken up into little bits by hand, to increase the surface area and expose more of the molecules to the water, to help remove any more of the fats and sugars that might be left.

4. The water is poured off and more added several times. During this time the cheese is further broken up by hand as it is in the water. When the water runs clear it is a good indication that no (or very little) fats and sugars remain.

5. After this process, the last of the warm water is poured off and cold water added– this helps it congeal and small particles that might be lost in the water are added to the mass and conserved.

FOR THIS DEMONSTRATION I HAVE ALREADY PERFORMED THE STEPS ABOVE – TO SAVE TIME.

6. The cheese is then mashed around on the large board, using the small board to further break it up. Use a bit of paper towel or cloth to blot off any whey that runs off. Put the large board on a towel to soak up spills - it helps a lot to contain the mess

NO PIC- but I will get one soon

7. Once no more liquid seems to be escaping, a base is added. Quick lime was used in the medieval period, it is a good base, but a bit strong, a safer alternative is "Pickling Lime" which can be purchased at most grocery stores. An estimated teaspoon of the pickling lime is first mixed into about a quarter cup of fresh warn water and stirred to completely dissolve it.

8. A bit of the cheese is added to the lime water and mashed around a bit. More cheese is added until it is blended up as much as can be.

9. The cheese mixture is turned out onto the board again and mashed up as much as possible using the smaller board against the larger board, much like grinding pigments with a Muller. It will take a bit of work to get a smooth consistency; it should be thickened, but not as thick as today's wood glue. **It will not feel sticky at first**, but it can be used at this stage. After a half hour or so you will notice it getting sticky.

I'll add more pics here

10. Once it is smooth, you can use it. Spread some on two bits off wood and join them together. You can "clamp" them by binding with twine. After several hours the wood should be well stuck

The pickling lime base (OH-) bonds to the H+ from the vinegar that was used to make the curds (or cheese) neutralizing the casein molecules. The micelles no longer bond to each other and will then collapse and break into long polymer chains, instead of holding the spherical shape (Guo & Wang, 2016). These polymers (long chains) have "arms" branching off them which then form crosslinks between themselves, this is what makes them stick together, and to other surfaces you apply it to – i.e. you have an adhesive, or glue.

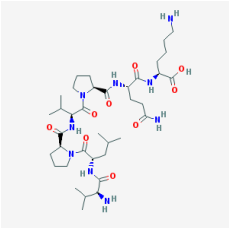

Figure III Polymers, MDPI.com, Switzerland

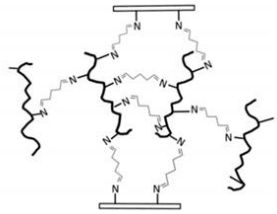

Figure IIII Image from Center for Biotechnology Information, US National Laboratory of Medicine

Casein glue does not store well, it must be used within a few hours of making it. Modern, industrial, casein glue has added components that make it storable. It is much used today and is the main glue to make modern ply wood, as it was in ancient times.

Addendum: I have been experimenting with making a casein glue that can be "stored" and used later in small quantities, as needed, rather than making a lot that is discarded after a few hours.

To do this I have not altered the ingredients at all. I have only altered the method by stopping it at one point, and then continuing it when glue is needed.

Specifically. Cheese curds, or low-fat cheese is washed and all the whey is removed, just as is done in the above instructions. At this point the process is halted. The resulting "washed curds/cheese" is then dried and ground into a powder. To do this the crumbled cheese curds are spread out on filter paper (coffee filters in this case) and left to dry. Once **completely** dry it is crushed into a rough powder (I will make it a fine powder next time). It was finer than this pic shows though.

I put half into one jar and set it aside. I put the other half into a different jar to which I added the pickling lime and set that aside.

A week later I checked both jars. There was an obvious difference in the appearance of the two powders. I first tested the jar with the pickling lime added (on the left in the photo), it appeared to be a more coarse powder than it was originally. I put a few drops of warm water with it and mixed it up. I stirred it and crushed it with the pestle as much as possible during this time. It was impossible to actually crush it. Unfortunately, after two hours it did not mix into a solution. I believe the lime bonded with the casein and was now solid. I rejected this method.

The jar of dried cheese curds only was tested next. This powder looked just as it had when originally put into the jar. To this I added some warm water. It too about an hour before it started to dissolve and go into a solution. It was stirred and crushed with the pestle several times. After the second hour it appeared to be well dissolved, with a milky look to it. At that point I added the pickling lime powder and stirred it. Immediately it turned yellow and became sticky.

It looked like cheese glue, but would it hold? I glued two sticks together and left them over night. The next day I could not separate them. But I needed to test if it was a watertight bond. I soaked half the glued sticks in water overnight.




The next day they were still bonded and could not be separated. Even my brother could not do so (we did not try prying with any tools, just used our hands).

For my next batch I will crush the dried powder smoother, and I will strain the reconstituted curds to get out lumps before I add the pickling lime.

Since only a small amount of glue is needed for paint brushes, this will make it a lot easier, and produce a lot less waste in the future.