White Paper on Cellulose and Polyurethane Sponges for Surface Sampling

The first publication on use of cellulose sponges for sampling surfaces in a food production environment was authored by Gabis and Silliker in 1975 (1). Since then cellulose sponges have been routinely used to sample a diverse range of samples including beef, pork and poultry carcasses (2, 3) to production floors, ceilings, drains and equipment. Alternative materials to cellulose sponges have been studied over the years. These materials include polyurethane sponges (4, 5), medical gauze, cotton and synthetic wipes (6, 7).

The ideal sample collection material is one that:

1. Is free of any toxic substances that would cause injury or be lethal to microorganisms after the surface sample has been collected and before the sample has been tested.
2. Is sufficiently rugged so that the surface can be vigorously scrubbed to disrupt and lift biofilm without disintegration of the collection material.
3. Is effective at collecting the microorganisms on the surface.
4. Releases all of the microorganisms during a procedure designed to count levels of microorganisms collected.
5. Does not interfere with a diagnostic test performed on the sample and produce false positive or false negative results.

This "White Paper" describes limitations associated with cellulose sponges for surface sampling and makes a case for utilization of polyurethane foam sponges as a preferred sample collection material.

Benefits and Potential Disadvantages of Cellulose Sponges for Environmental Surface Sampling

The benefits of cellulose sponges for surface sampling include the following:

1. Cellulose sponges have been used for at least 40 years in the U.S. for surface sampling.

2. There are peer-reviewed studies on recovery rates with cellulose sponges, especially for microorganisms on carcass surfaces.

3. Cellulose sponges have been recommended by the USDA for carcass sampling.

4. One manufacturer of cellulose sponges has consistently produced and supplied biocide-free cellulose sponges for the U.S. market for at least 20 years.

The potential disadvantages of using cellulose sponges for surface sample collection include the following:

1. Supply Chain Vulnerability: There has only been one manufacturer of cellulose sponges that has historically provided food industry and manufacturers such as World Bioproducts with biocide-free sponges. This has resulted in a troubling dependence on this supplier to meet the worldwide demand for biocide-free cellulose sponges.

2. Potential for Residual Quats in Sponge: Cellulose sponges are manufactured for consumer use such as general surface cleaning (dishes, kitchen work surfaces, automobiles, etc). Because the manufacturing of cellulose sponges is a "wet" process and susceptible to growth of molds and other microorganisms, quaternary ammonium compounds are used by manufacturers to inhibit growth of these contaminants (8, 9).

   Cellulose sponges used for microbiological sampling must be free of quaternary ammonium compounds. Manufacturers of sampling devices need to stipulate to their supplier that the cellulose sponge be manufactured without the inclusion of the quaternary ammonium compounds. Then, it is necessary for the manufacturer of the sampling devices to confirm that the material is indeed free of inhibitory substances through testing.

3. Batch to Batch Inconsistency: Cellulose sponges are manufactured using natural materials such as wood pulp and vegetal fibers. This means that, batch to batch, cellulose sponges may have different chemical and/or mechanical properties.

4. Extraneous Materials from Manufacturing Process: Diagnostic procedures that are intended to detect very low levels of microorganisms in a sample and may be susceptible to interference by extraneous material from the sponge causing false positive or false negative results. The manufacturing process includes many steps where interfering substances could be introduced. (Please see Attachment #1 at the end of this paper that illustrates a typical cellulose sponge manufacturing process.) Impurities such as heavy metals and chloro-organic compounds could be introduced by the water used to produce and wash the sponge. Residual sulfur from the manufacturing process has been identified as a potential inhibitory material in cellulose sponges (8). Carbon disulfide and sodium sulfate are critical components to the cellulose sponge manufacturing process.

5. Low pH Sponges: The medium to large pores in cellulose sponges are formed by sodium sulfate crystals. These crystals make the cellulose sponges acidic, with the pH of a dry compressed cellulose sponge below 6. If a hydrating solution with low buffering capacity (such as Butterfield's phosphate buffer) is used to hydrate an acidic cellulose sponge, the operative pH may be too low to assure long term survival of microorganisms collected on the sponge.

6. Sampling Rough Surfaces: Cellulose sponges with medium to large pores are highly effective at quickly absorbing and retaining liquid. These sponges however are susceptible to abrading. Consequently, cellulose sponges that are rubbed across sharp and abrasive surfaces during sampling may flake, leaving behind small pieces that may remain on the sampling surface or equipment. Leaving behind pieces of cellulose sponge is an obvious concern for food industry with the possibility for sponge fragments entering a product.

Potential Benefits of Polyurethane Sponges for Environmental Surface Sampling

1. Non-Toxic: Polyurethane sponges that are being used by World Bioproducts are non-toxic and do not contain biocides. Unlike the "wet" cellulose manufacturing process, there is no need to include biocides to control microbial growth during the polymerization process to produce polyurethane

sponges. Moreover, these polyurethane sponges have been subjected to cytotoxicity testing and have shown no toxicity in these tests.

2. Routinely Used in Medical Devices: Unlike cellulose sponges, polyurethane sponges have a long history of use in medical products that are in contact with the body (e.g. wound dressing) or inside of the body (e.g. wound drainage) because of their non-toxic properties and other attributes such as tensile strength.

3. Batch to Batch Consistency: The polyurethane sponges utilized by World Bioproducts are manufactured using high purity raw materials and well controlled manufacturing processes. Consequently, the chemical and mechanical properties of the polyurethane sponges are consistent from batch to batch.

4. Strong; High Tensile Strength: These polyurethane sponges are less susceptible to flaking and tearing when sampling an irregular and abrasive surface. Therefore, rigorous scrubbing of a rough surface can be done with minimal to no sponge fragmentation.

5. Good Water Absorbency and Retention: The polyurethane sponges that World Bioproducts uses are capable of absorbing up to 15 times their weight in water. Like cellulose, these polyurethane sponges release liquid only under pressure. Consequently, the amount of liquid applied to a surface during sampling is comparable between cellulose and polyurethane sponges.

References

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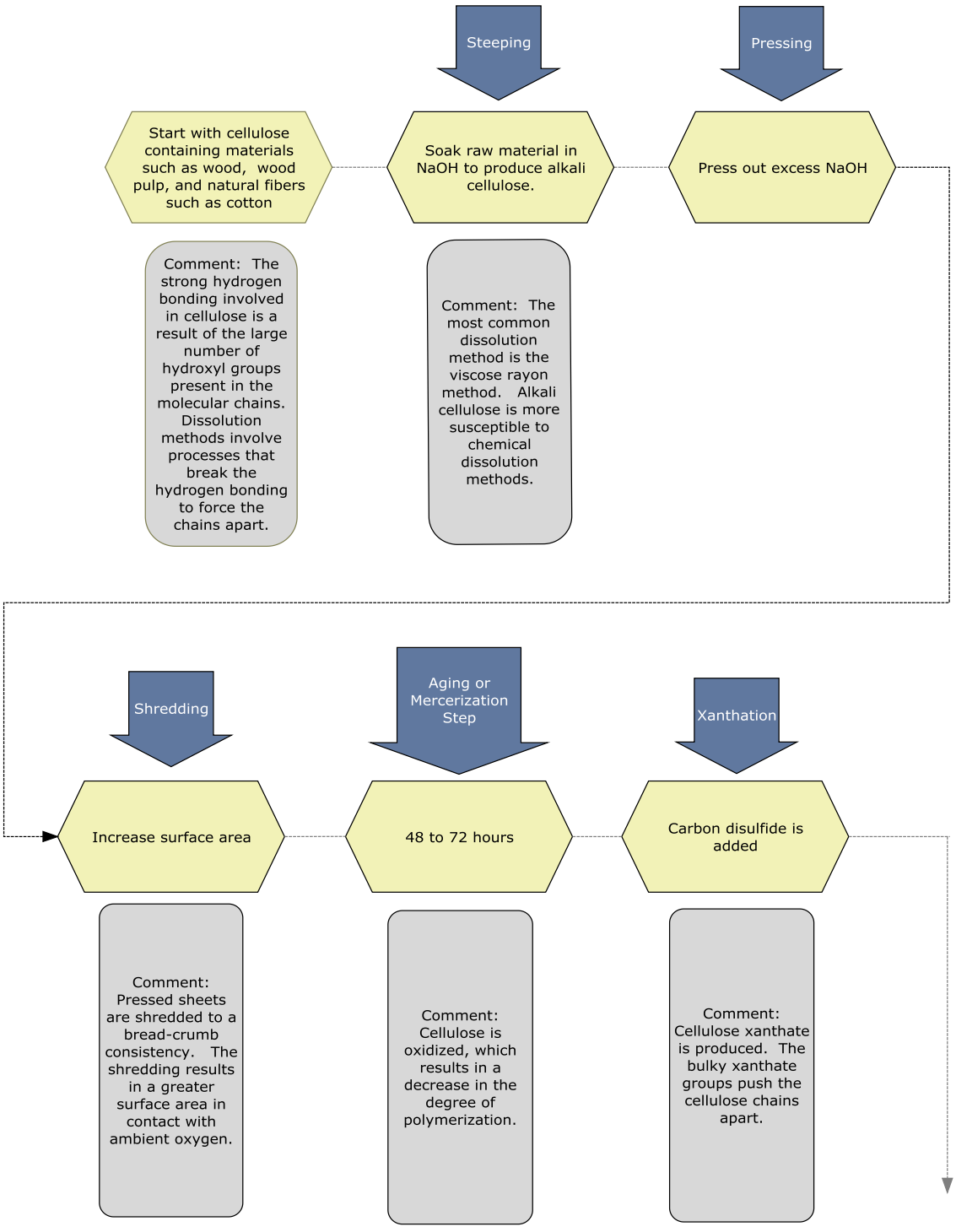
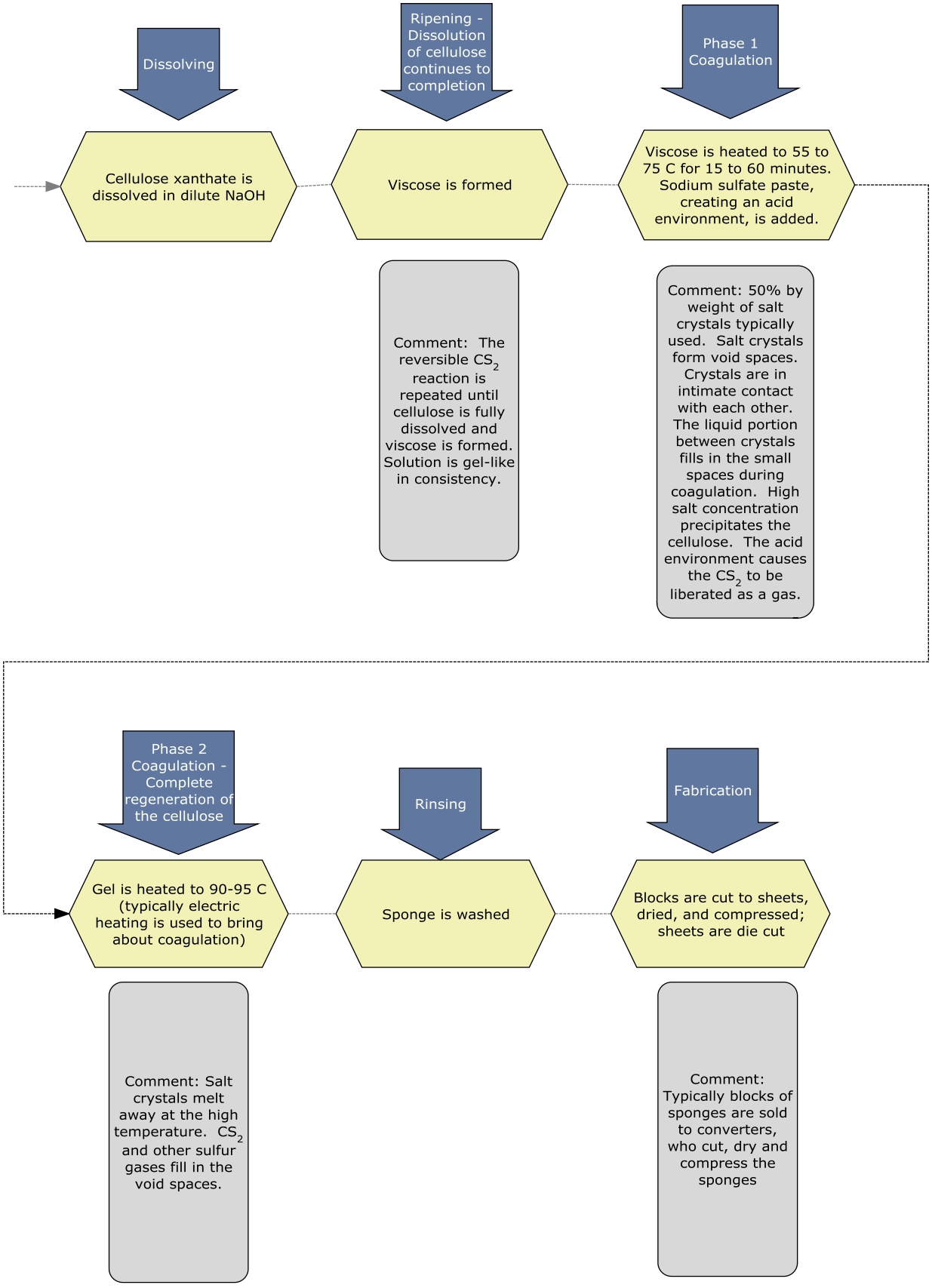
Attachment #1

Cellulose Sponge Manufacturing - Viscose Process with Electrical Coagulation




Dissolving
Ripening - Dissolution of cellulose continues to completion
Phase 1 Coagulation
Cellulose xanthate is dissolved in dilute NaOH
Viscose is formed
Viscose is heated to 55 to 75 C for 15 to 60 minutes. Sodium sulfate paste, creating an acid environment, is added.
Comment: The reversible CS_2 reaction is repeated until cellulose is fully dissolved and viscose is formed. Solution is gel-like in consistency.
Comment: 50% by weight of salt crystals typically used. Salt crystals form void spaces. Crystals are in intimate contact with each other. The liquid portion between crystals fills in the small spaces during coagulation. High salt concentration precipitates the cellulose. The acid environment causes the CS_2 to be liberated as a gas.
Phase 2 Coagulation - Complete regeneration of the cellulose
Rinsing
Fabrication
Gel is heated to 90-95 C (typically electric heating is used to bring about coagulation)
Sponge is washed
Blocks are cut to sheets, dried, and compressed; sheets are die cut
Comment: Salt crystals melt away at the high temperature. CS_2 and other sulfur gases fill in the void spaces.
Comment: Typically blocks of sponges are sold to converters, who cut, dry and compress the sponges