

**A productive history.  
A promising future.**



*Cellulose acetate tow offers sustainable benefits  
for the cigarette filter market.*



# A productive history. A promising future.

The Global Acetate Manufacturers' Association (GAMA) is comprised of some of the leading companies in the cellulose acetate business. They have implemented a number of measures to ensure sustainability is at the top of the agenda in all their business practices. GAMA and its member companies intend this brochure to serve as a useful tool in education about the cellulose acetate tow product and trust that it will bring awareness to the sustainable aspects of cellulose acetate.

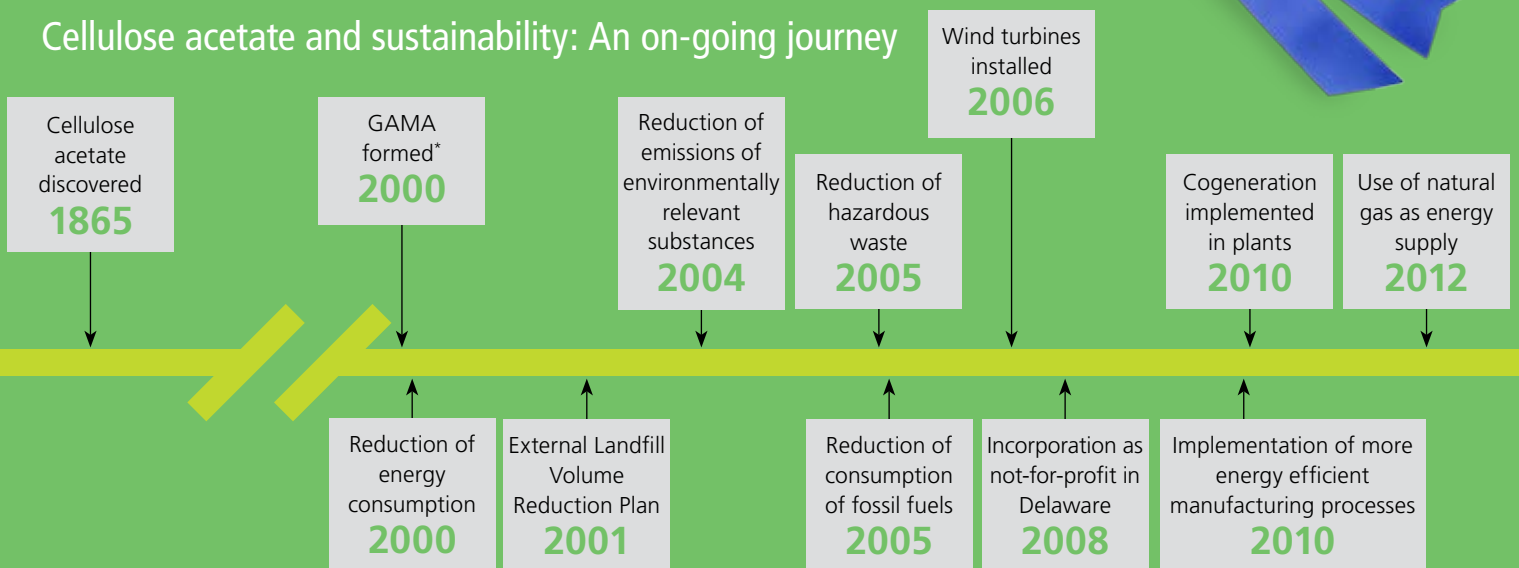
Derived from natural resources, cellulose acetate is a man-made material that can be found in many everyday products. It is commonly used in commercial cigarette filters, reservoirs for ink pens, and membrane separation and filtration products. You'll also find it in fabrics for clothing, window treatments, medical tapes and devices, and upholstery.

Proven more than useful since its introduction in 1904, cellulose acetate also has many properties that make it an effective and sustainable choice for product manufacturers.



Found in everyday products, cellulose acetate is a man-made material derived from natural resources.

## Cellulose acetate and sustainability: An on-going journey



\*Gama was incorporated as a Belgian AISBL in 2000. Although a formal definition of Sustainability was created more recently, member companies began establishing Formal Sustainability Goals in the 1980s.

## A renewable resource

The raw material used to manufacture cellulose acetate tow is renewable plant-derived cellulose, the structural component of the primary cell wall of green plants. The most common source of cellulose is pulp derived from trees, a naturally occurring resource which is sustainable when sourced from well-managed forests that are conscientiously harvested and replanted with future generations in mind.

### *Protecting raw materials*

Trees are an integral part of the manufacture of cellulose acetate, but most importantly, they are an integral part of the Carbon Cycle. CO<sub>2</sub> has long been recognized as a “Greenhouse Gas,” capable of both converting solar energy traveling through the Earth’s atmosphere to radiant energy, and then trapping that radiant energy at the Earth’s surface.

Although the overall impact of CO<sub>2</sub> generated from human activities on Global Climate Change remains a highly debated topic, it is commonly agreed that removal of this vital link in the CO<sub>2</sub> cycle without replenishment would result in a significant accumulation of CO<sub>2</sub> in the atmosphere.

To protect the population of a vital resource like trees, much of the wood pulp used for the production of cellulose acetate is obtained under third-party forest certification standards. Examples of such certification standards are the Sustainable Forestry Initiative® Inc. (SFI)<sup>[1]</sup> and the Forest Stewardship Council (FSC).<sup>[2]</sup>

## A sustainable process

### *Production of cellulose acetate tow*

GAMA members strive to minimize resources—such as energy and water—at every stage of manufacturing. Combined with acetic acid, a simple organic acid, and the main component of vinegar, the natural polymer cellulose is modified to form cellulose acetate in the form of flakes.

### *A closer look at principle manufacturing steps*

#### **STEP 1: Activation of cellulose**

The cellulosic raw material (e.g., wood pulp) is mixed with acetic acid and a sulfuric acid catalyst under mechanical stress, resulting in a homogenous slurry. Thereby, the cellulose fibers are made equally well accessible for the reaction; and the even distribution of the reagents is facilitated and ensured.

#### **STEP 2: Acetylation**

Acetic anhydride is added to the mixture from the activation step and reacts to form fully acetylated cellulose (cellulose triacetate) and acetic acid.

#### **STEP 3: Hydrolysis**

For many applications, fully acetylated cellulose does not offer the desired properties (e.g., with respect to solubility). Therefore, water is added to the mixture from the acetylation step to remove a certain number of acetate groups from the cellulose acetate polymer molecules. Around 20% of the acetate groups are removed—resulting in cellulose diacetate (actually a cellulose-2.5-acetate), which is soluble in acetone and used for filter tow and textile fibers production.





#### STEP 4: Precipitation and processing

Cellulose acetate is precipitated in the form of flakes by the addition of larger amounts of water. Subsequently, the flakes are washed with water to remove remaining acid. To form the final product, the flakes are dried.

After cellulose modification and flake production, the flake is used to produce tow through a manufacturing process including spinning, crimping, and drying.

#### STEP 1: Preparation of the spinning solution

Cellulose acetate flakes and acetone are mixed together intensively. A small amount of titanium dioxide is added as a delustering agent for later product. To achieve a spinning solution free of particles able to block the spinnerets, the mixing is followed by an intensive filtration.

#### STEP 2: Spinning

After passing the spinneret of a spinning cell, the acetone starts to evaporate from the spinning solution. The evolving filaments are solidifying and being brought together while the acetone is almost completely removed and recovered.

#### STEP 3: Crimping

The resulting filaments from numerous spinnerets are combined to form a cable of up to several tens of thousands of filaments. These cables are subsequently crimped in a stuffer box to obtain the typical filter tow structure.

#### STEP 4: Drying and processing

The fresh crimped structure is fixed by drying, and the filter tow is compressed in bale presses to form filter tow bales.

#### STEP 5: Production of cigarette filter rods

After manufacturing the tow bale, the product is then ready to be sold and shipped to third-party customers who then make cigarette filter rods.

## Resource management

From raw material to finished product, the consumption of natural and man-made resources is carefully considered. Cellulose acetate production stems from the responsible use of energy, water, and raw materials to efficiently create effective end products in applications such as cigarette filters. A close management of resources helps cellulose acetate stand out among alternatives.

#### Energy

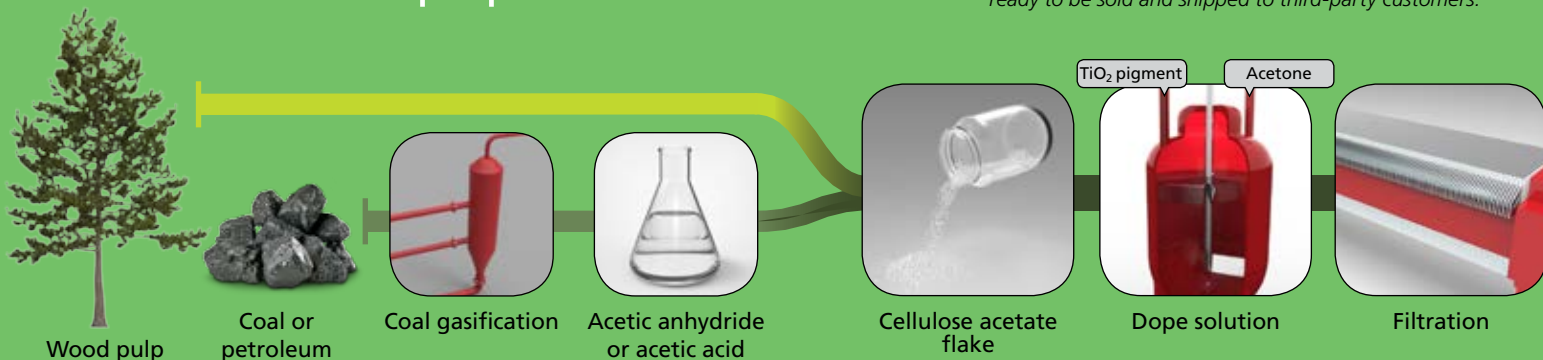
- While cellulose acetate requires a higher energy usage associated with feedstock requirements and biomass energy for production than polyester and polypropylene,<sup>[3]</sup> overall cellulose acetate requires less energy than these materials due to production process demands. Another alternative, polylactic acid (PLA), also requires higher energy demands associated with the production process than cellulose acetate.<sup>[3]</sup>

#### Water

- Very little water is required in the manufacturing process for cellulose acetate. Most of the water demands for cellulose acetate lie in the cooling process.<sup>[3,4]</sup>
- Any water that is returned to the environment must meet strict quality standards set by local, state, and federal agencies.

## Manufacture and properties of acetate tow

After the tow bale is manufactured, the product is then ready to be sold and shipped to third-party customers.



- Quite often, the water returned to the environment by cellulose acetate manufacturers surpasses these requirements.

### Renewability of raw materials

- Much of the wood pulp for cellulose acetate manufacturing comes from trees grown in responsibly managed forests, giving cellulose acetate its sustainable foundation. To make cellulose acetate, the cellulose requires modification by acetic acid. Viscose is also produced through the modification of cellulose, just like cellulose acetate. However, different chemicals are used to modify the viscose. The cellulose is reacted with caustic soda then carbon disulfide, which is only partially recovered, instead of acetic anhydride.<sup>[5]</sup> The recovery rate of the chemicals used in the process determines its sustainable advantages.
- PLA is produced through a fermentation process of corn or some other raw material. This process competes with food production, however.<sup>[6,7,8]</sup>
- Polypropylene and polyester are oil-based fibers. Oil is a very limited resource that lacks the renewability of trees.<sup>[4]</sup> These fibers are considered the least advantageous of all in this category, due to the nonrenewable nature of the raw materials required for production.

### Biodegradation

- Cellulose acetate can biodegrade at ambient temperatures whereas PLA requires temperatures above 50°C.
- Cellulose acetate is much more biodegradable than aromatic polyesters and polypropylene. These substances are considered nonbiodegradable due to their high crystallinity and/or hydrophobicity.<sup>[9,10]</sup>

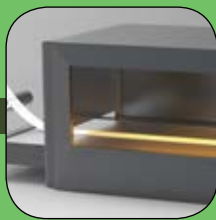
In the overall spirit of sustainability, the use of a renewable resource such as wood pulp as the major raw material means that the cellulose acetate industry has always been and will remain at the forefront of sustainability efforts.



Spinning



Crimping



Conditioning



Baling



Pressing/packaging



Finished bale

## Developing degradable tow

To continue the cycle of sustainability, it is important that materials have the ability to degrade. Cellulose acetate is degradable in the environment by a variety of mechanisms, mainly by biodegradation by microbes. Many studies have shown that biodegradation occurs in different environments including soils, composts, and waste water treatment facilities. The key characteristic of the biodegradation of cellulose acetate is the progression in two steps:

1. In the first—usually slower—step, acetyl groups are removed.
2. Then, the breakdown of the remaining cellulosic structures occurs.

Photodegradation can facilitate the attack of microbial enzymes during biodegradation by enhancing, in particular, the first step. The photodegradation of cellulose acetate happens by so-called secondary mechanisms, which comprise other substances (e.g., air, water, additives) absorbing light and generating radicals that react in a degrading way with the cellulose acetate structure.

Another mechanism that supports biodegradation is chemical degradation, which also results in the elimination of acetyl groups (by hydrolysis) and occurs naturally during composting and other environmental processes. Additionally, the acetic acid formed by chemical degradation can serve as a food source for microorganisms involved in biodegradation.

Disintegration (physical disassociation of an article in smaller pieces) is not regarded as a type of degradation in terms of transferring the elements back into the natural life cycle. The ability to disintegrate is not a question of the chemical nature of a material but of product design. In contrast to the degradation mechanisms described previously, disintegration is a purely physical process that leads to smaller units of the material. However, it can support other degradation mechanisms by providing a larger contact surface.<sup>[11]</sup>

## Practicing sustainability

Members of GAMA recognize the importance of sustainable practices and are making great strides in adopting such practices to reduce our impact on the environment. These include a reduction in emission, waste, water consumption, and energy use while building programs for wind energy, integrated environmental impact analysis, social initiatives, and sustainable home practices.

The following examples of sustainable practices are being undertaken across the cellulose acetate industry.



### Reduced emissions

A common goal among GAMA member companies has been the reduction of air emissions, ranging from general categories like volatile organic compounds (VOCs) and greenhouse gases (GHGs), to specific substances like carbon dioxide, nitrogen oxides, and sulfur dioxides. The average reduction in VOCs among member companies has been approximately 30%. GHG reduction was slightly more variable, with reported values up to 50%. In some instances, process and equipment improvements have allowed member companies to achieve up to a 56% reduction in nitrogen oxides and sulfur dioxide emissions.



### Waste reduction

Waste reduction can be accomplished through an increase in the efficiency of material use and through reuse and recycling of materials that have historically gone to disposal. Through various waste reduction mechanisms (including bulk and small container reuse, metal recycling, and light bulb and battery recycling), member companies have met significant milestones, such as a 20% reduction in landfill volume and a 40% reduction in total waste volume.

## What is sustainability?

Sustainability begins with a focus on mindful and conscious actions that emphasize impact on the environment, both short-term and long-term. It calls for an emphasis on the reduction of any negative effects by considering the environmental implications, social responsibilities, and economic growth potential associated with the product or process. Moreover, sustainability is an ongoing endeavor.



### **Wind energy**

Wind energy is considered a source of clean, nonpolluting electricity. At least two GAMA member companies have implemented the use of wind energy at their manufacturing sites. These member companies were able to generate anywhere from 25%–50% of their total energy required for operations at their respective sites. The use of a renewable energy source allowed one site to reduce CO<sub>2</sub> emissions by approximately 9,000 tons annually.



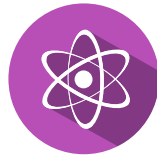
### **Reduction in energy consumption**

Cogeneration is a strategy that has been employed by several member companies as a means of achieving higher energy efficiencies. Cogeneration is when a single energy source, such as coal or clean natural gas, generates both steam and electricity. This process is far more energy efficient than processes that generate only steam or only electricity. Reduction in energy consumption can also be achieved through the implementation of new, eco-friendly processes that have lower energy (e.g., steam, heat, electrical) requirements. Through various cogeneration processes, member companies have achieved reductions in overall energy consumption ranging from 17%–50%. The shift from coal to clean natural gas has also reaped an additional benefit of reduction in CO<sub>2</sub>.



### **Reduction in water consumption**

Water is used at many points in the manufacture of cellulose acetate. Reduction in water consumption is possible through manufacturing process optimization. Recycling the water remaining at the end of the process back to the beginning stages also allows for reduced consumption and reduced effluent emissions. Various member companies have implemented process changes and improvements that have allowed them to achieve up to a 75% reduction in total water consumption.



### **Integrated environmental impact analyses**

With all of the individual steps taken toward becoming a more sustainable organization, GAMA member companies can tie it all together by establishing an environmental accounting system to summarize the overall cost/benefit ratio efforts. By assigning monetary benefits to different aspects of sustainability, it is easier to visualize the cost/benefit ratio, as well as put the results into overall perspective.



### **Social initiatives**

GAMA member companies are involved in different social initiatives at local and global levels. In general, member companies participate in a wide variety of corporate social responsibility activities ranging from fundraising financial support for reconstructions after earthquakes to assisting in combating fires after an accident at a neighboring manufacturing site to service-based activities in their local communities. In this manner, member companies give back to their communities through hard work and caring.



### **Taking sustainability home**

While the concepts of sustainability have significant global impact when followed by manufacturers, what would happen if those same concepts were a part of everyone's daily life, even away from work? GAMA member companies address that question by implementing educational programs that encourage employees to save energy at home. With a total of 10,000 employees, for example, including employees and family members, the per capita CO<sub>2</sub> emissions reduction can exceed 0.9 kilogram per person per day and the aggregate CO<sub>2</sub> emissions reduction would total 2,971 tons.

## Conclusion

Since its discovery, cellulose acetate has proven itself as an effective material for a number of applications. Almost one million tons of cellulose acetate are manufactured and distributed yearly for use in numerous everyday products. GAMA knows and values the importance of responsibly producing cellulose acetate to meet the demands of modern markets. The cellulose acetate industry is aware of the role it plays as a responsible environmental steward, understanding the importance of incorporating environmentally conscious practices and focusing on global preservation of natural resources.

Since the creation of GAMA in 2000, progress in sustainable practices throughout the industry has been a key objective for all member companies. GAMA will continue to move forward as an entity dedicated to the careful management and responsible use of today's natural resources. Through this brochure, member companies hope to have demonstrated the commitment of this industry to playing a role in preserving the planet now and for future generations.

## About GAMA

To represent the worldwide cellulose acetate industry, the Global Acetate Manufacturers' Association (GAMA) was founded in 2000. Its members are committed to fostering and promoting the usage of cellulose acetate, while at the same time addressing health, security, and environmental issues associated with its processes and products.

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To learn more about GAMA and the sustainable benefits of cellulose acetate tow, visit [www.acetateweb.com](http://www.acetateweb.com) or [GAMA@kelleneurope.com](mailto:GAMA@kelleneurope.com).

Sustainability is an ongoing endeavor—  
one that this industry readily and eagerly embraces.