cottonworks™
BY COTTON INCORPORATED

Considerations When Evaluating Traceability Solutions

Cotton Incorporated works with companies and technology providers to help companies make informed decisions about cotton traceability. Although not all information about traceability technologies is publicly available, Cotton Incorporated has identified characteristics and capabilities of these methods for companies to consider when thinking about traceability solutions.

Even when providers' websites give detailed information about the technologies, descriptions of processes tend to be vague, and performance claims need to be confirmed or qualified. Before making decisions, companies will likely need to ask providers for further information or a demonstration. Testimonials or user reviews of specific offerings also can be helpful.

The Three Main Traceability Methods

Cotton traceability methods fall into three general categories:

FEATURE	1 Taggant	2 Forensic	3 Chain of Custody
DEFINITION	Physical or chemical marker added to cotton	Tests inherent chemical characteristics of cotton	Tracks movement and handling through the supply chain
KEY TECHNOLOGIES	DNA markers, luminescent tracers, pigments	Isotope and trace element analysis	Blockchain, record-keeping platforms
BEST FOR	Verifying specific origin claims	Confirming geographic origin	Aids in compliance and transparency
CHALLENGES	Cost, detection levels after blending and processing	High cost, long turnaround times, detection levels after blending and processing	Requires rigorous data input and maintenance

These methods may be used separately or in combination, depending on a company's traceability needs and goals. This paper briefly describes these three methods, followed by key points for companies to consider when deciding on a traceability approach.

1 Taggant Methods

A taggant may be added to raw cotton, processed fiber, yarn, or fabric by spraying or injection. Chemical taggants are detected via laboratory analysis. Physical taggants *(such as pigments)* typically are microscopic, added at low levels, and detected with scanners. The following types of markers may be applied:

- Synthetic DNA molecular tags are applied to raw cotton, fiber, yarn, or fabric and detected through polymerase chain reaction *(PCR)* analysis of samples.
- Luminescent tracer materials are applied to raw cotton, fiber, yarn, or fabric and detected with optical scanning devices.
- Manufactured cellulosic fibers containing combinations of luminescent pigments are injected into raw cotton at the gin or added during spinning to create an "optical fingerprint" readable by sensors.

Special Considerations with Taggant Technologies

The addition of tracer substances to cotton raises questions about their nature and the methods by which they are added and detected.

In particular, if a marker is applied to cotton that is subsequently blended, what exactly does testing of the blended product detect? For interpretation of the test results, it may be necessary to combine taggant technology with chain-of-custody tracking.

Questions:

- What is the exact chemical and physical nature of the substance added?
- Does the substance pose any environmental concerns? Is it subject to global or local regulations?
- At what point in the supply chain is the substance added?
- What degree of coverage does the tagging process provide? Is application uniform? If the substance is applied to raw cotton, is every fiber marked, or some known or unknown percentage of fibers?
- Is the substance stable over time and under changing environmental conditions, and will it withstand chemical and mechanical textile manufacturing processes?
- Can the substance inadvertently be transferred to machinery or to untagged material?
- Will the substance affect the properties and processing of the tagged cotton, including quality, feel, or durability?
- How does the detection method work? Does it provide quantitative results indicating the amount or proportion of marked cotton in a sample? Or does it simply detect that the taggant is present?

2 Forensic Methods

Forensic methods are based on the fact that the environmental growing conditions affect the chemical composition of cotton fiber. Forensic methods rely on chemical analysis of product samples:

- Samples are analyzed for ratios of light stable isotopes *(oxygen, hydrogen, and carbon)* and for the presence of trace elements.
- The results are compared against a library of chemical profiles of cotton grown at known geographic locations.
- Products may be analyzed at any point in the supply chain.

Special Considerations for Forensic Technologies

Relatively few providers offer forensic testing of cotton, and it is not a main focus of their business. Compared with taggant technologies, testing is expensive, and turnaround times are long. The use of forensic testing requires that the company document the sample's chain of custody from the point of collection to the test provider.

U.S. Customs and Border Protection *(CBP)* uses isotopic testing to screen high-risk cargo, such as cotton from the Xinjiang Uyghur Autonomous Region, and supports companies' use of isotopic testing as a tool in supply-chain tracing of origin. CBP suggests that providers' laboratory methods and data interpretation conform to guidance from the Forensic Isotope Ratio Mass Spectrometry Network Good Practice Guide and that the laboratories seek accreditation under ISO/IEC 17025.

Questions:

- How stable is cotton's chemical composition during storage and textile processing?
- Are the results affected by cotton species, differences in agricultural practices, or shifts in soil or climatic conditions? What other non-geographic factors might influence the results?
- Can the provider analyze materials containing blends of fibers? What methods does the provider use to isolate cotton from blends?
- How extensive is the provider's library of reference materials? How well does it represent the world's cotton-growing regions? How is the library maintained over time?
- At what resolution can regions of origin be distinguished from each other? Can subtle differences between regions be detected?
- What volume of sampling is required to provide reliable results? What is the statistical confidence in the test results?
- What information does the provider include in test reports? Does the provider document the chain of custody of the sample from receipt through disposition?
- Will the test results be timely, and will the scale of testing justify the cost?

3 Chain-of-Custody Methods

At its simplest, a "chain of custody" is a chronological record of who has had custody of the product at each point in the supply chain, from sourcing to retail. Chain of custody can be used to track cotton from a specific origin as it moves through the supply chain:

- Data can be collected and recorded at each point in the supply chain.
- Blockchain technology can be used to create a decentralized, unalterable information trail that can be shared by all stakeholders.
- In addition to tracking geographical origin, providers have developed tracking systems to support regulatory compliance; certification of organic production; sustainability; life-cycle analysis of environmental impact; carbon accounting; tracking of environmental, social, and governance impacts; circularity; product quality assurance; counterfeit detection; supplier risk audits; and customer engagement.

Special Considerations for Chain-of-Custody Methods

There is a growing market for chain-of-custody tools that can track products from their origin through processing, manufacturing, and consumption. Some tools have been developed to support the tracking of many different product types, while others have been developed specifically for the textile industry. Platforms can often be customized.

Traceability platforms generally allow various types of data to be recorded and analyzed at each point in the supply chain. Some chain-of-custody providers have implemented blockchain technology, which offers particular advantages for tracing complex supply chains, as well as being tamperproof and transparent.

Relying solely on chain of custody to document the origin of cotton is the least expensive approach to traceability. Chain of custody can also be valuable in combination with taggant or forensic traceability technologies, to document traceability testing results throughout the supply chain and potentially to aid in interpretation of results. Some providers have designed their systems to integrate taggant or forensic technologies with chain-of-custody methods, including blockchain

General Considerations with Traceability Technologies

These are major considerations in evaluating taggant and forensic traceability technologies:

- The implications of blending — with cotton from different sources or with other types of fibers — and the stages at which blending occurs, from ginning through sliver and roving formation to knitting or weaving.
- The effects of textile processing on the test's reliability — whether the technology can withstand the mechanical and chemical processes of textile manufacturing.
- The level of sampling required to ensure test results with a high level of statistical confidence.

Companies need to consider the following questions in evaluating which cotton traceability solutions will best meet their needs.

Single-Origin Cotton vs. Blends

- How effective is the technology at confirming that *(1)* products contain only cotton from a single origin or *(2)* products contain no cotton from a particular origin?
- How effective is the technology at tracing cotton from a specific source after it has been blended with *(1)* cotton from other sources or *(2)* other types of fiber *(plant, animal, synthetic)*?
- How much marked cotton must be present in a sample *(percentage content)* in order to be detectable?
- Does the technology measure the percentage of marked cotton in a sample, or simply its presence or absence?
- What are the accuracy, error, and precision of the testing method?

Processing or Supply-Chain Stage

- At what stages in the supply chain does cotton need to be tracked?
- At which stages of production is the technology effective — with raw fiber, processed fiber, yarn, greige fabric, finished fabric, or manufactured and laundered products?
- Do the accuracy, error, and precision of testing differ at different stages in production or points along the supply chain?

Availability and Cost

- How readily available is the technology for use with cotton? Does the provider's location matter *(domestic vs. overseas)*?
- What is the cost? Cost information generally is not published, and providers base their estimates on the size, scope, and volume of the testing program and the specific services desired.
- What is the turnaround time for test results?

Assurances

- What level of statistical confidence does the test provide?
- If origin is "certified," what assurances does the provider give about the certainty of the findings, and on what basis?
- How vulnerable is the technology to fraud?

Conclusion

Selecting a technically effective and cost-effective cotton traceability solution requires a company to understand its own needs and goals for traceability and to seek detailed information from the providers.

For More Information:

Contact Cotton Incorporated for guidance on evaluating traceability solutions for your business.