Fiber Innovation Technology, Inc.

presents

New Fibers for Taggant Applications **or** *ChickenHead to the Rescue!*

by

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New Fibers for Taggant Applications

or

ChickenHead to the Rescue!

It's sad to reflect on the miserable state of affairs in the superhero world today. All the major superheroes seem to be so busy signing movie deals and promoting fast food that they can't be bothered to save us from a petty global crisis. Witness this list of emergencies currently being ignored by all the major superheroes:

- terrorist bombings destroy lives and property and introduce widespread fear and chaos;[1]
- "mad-cow disease" forces the destruction of whole herds of innocent and valuable cattle;[2]
- a newly-virulent avian flu threatens a global epidemic;[3]
- counterfeit and forged securities and banknotes threaten local and global economies;[4]
- valuable brands and associated businesses are depreciated by product counterfeiting;[5]
- international rings of jewel thieves operate with excessive impunity[6], and
- a fear of genetically-modified food is so severe that starving populations in Africa are forbidden to eat donated corn because it cannot be certified "GM-free."[7]

So it is my great pleasure to breathlessly introduce a new superhero with superpowers useful in fighting each of the problems listed above. Created by a crack team of scientists in gleaming, top-secret state-of-the-art research laboratories buried deep beneath the mountains of northeast Tennessee, it's the not-yet-contractually-obligated-to-any-major-motion-picture-studio…**ChickenHead™** !

Okay, in truth, "ChickenHead" is merely an imaginative name for a new fiber. But this new application of advanced fiber technology really does provide a way to counter each of the problems in the rather daunting list above, as well as many others. The name "ChickenHead", as will become apparent, comes from a bicomponent cross section that is proving particularly useful as one of a class of materials known as "taggants."

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[1] http://www.cnn.com/US/OKC/bombing.htm

[2] "Bovine Spongiform Encephalopathy in a Dairy Cow --- Washington State, 2003," *MMWR,* January 9, 2004/52(53);1280-1285.

[3] "Avian Flu," CBC News Online, April 7, 2004, http://www.cbc.ca/news/background/flu/avianflu.htm.

[4] "IG Agents Break 100 Billion Dinar Counterfeit Ring in Iraq," United States Department of Defense news release, Oct. 1, 2003.

[5] Levi Strauss vs. Sunrise International Trading Co., U.S. District Court for the Southern District of FLorida, no. 93-6547-CIV.

[6] "Jewel Exhibitors Lose Millions to Sticky Fingers," Dow Jones Newswires, Mar. 4, 2004, 04:02 GMT.

[7] "Angola's Plan to Turn Away Altered Food Imperils Aid," *The New York Times,* March 30, 2004.

Today's Taggants

Taggants, broadly defined, are a means for marking an item in a way that uniquely identifies the item without making it obvious to the consumer that the item has been so marked, and without adding hazards to the consumer or degrading the product's performance. This then allows the product to be traced to its origin for such purposes as authentication, quality control or for forensic purposes. Typically, taggants are microscopic particles that are added to a product. They need to be small so that they're not conspicuous and so that they do not interfere with the desirable properties of the marked item. But in addition to being inconspicuous, they need to be easy to locate and they often need to carry a large amount of information. For most taggants, it is also critical that the taggant be difficult to counterfeit.

In currency and security papers, taggants can be used to assure authenticity. In these applications, the taggant may appear in the form of a fiber that responds in a distinct way when excited by energy of a specific wavelength. A simple example of this approach would be a fiber carrying a fluorescent dye, but many taggants currently in use employ materials that provide a more sophisticated response. Another form of taggant found in security papers is the *planchette*, which is a small, thin wafer, typically made of plastic, with a characteristic shape. Such taggants commonly provide only a binary indication of authenticity, but do not provide higher-resolution data such as the date of issue or identity of the paper's proper owner or anything beyond simply whether the paper's source is authentic.

RFID tags are a newly-popular taggant finding use in marking retail items such as clothing. Because they can store electronic data that can be encrypted and wirelessly interrogated, they can provide a large amount of information that is easily retrieved and presumably difficult to counterfeit. They are typically small enough to unobtrusively reside on or in garments. They are also small enough that the European Union plans to issue banknotes with RFID devices in 2005[8]. But the size of even the smallest RFID tags is still too large for dispersal in bulk materials like corn or explosives, and the cost, currently at 25-50 cents each, with prospects of price reductions down to 5-10 cents each[9], is still too high for such applications, as well.

One technique employed for marking bulk explosives is the inclusion of small plastic pellets that have been coextruded with multiple layers of differing color. The color sequence works like a barcode, and can provide a large amount of information at relatively low cost and with a suitably small size. The inedibility of these particles renders them useless for marking such products as foods and pharmaceuticals, though, and even in marking explosives they are less than ideal. The purpose of marking explosives, after all, is not so much for quality control or to prevent counterfeiting as to provide forensic evidence in the aftermath of a criminal detonation. After a detonation, there is the difficulty of locating the particles, which may easily have been dispersed far

[8] Yoshida, Junko, *Euro Banknotes to Embed RFID chips by 2005*, "EE Times," December 19, 2001.
[9] McKinsey, 2003.

from the detonation site by the force of the explosion. A more two-dimensional particle would be expected to more reliably remain close to the site of the explosion.

So in many applications where taggants are useful, existing solutions may be less than optimal, and in other applications where taggants are wanted, no fully acceptable solution has yet been proposed.

Bicomponent Fiber Taggants

In the late 1990s, Fiber Innovation Technology was experimenting with bicomponent fibers having an “islands-in-the-sea” cross section. (Fig. 1).

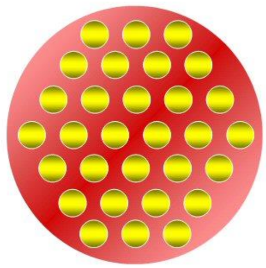

Figure 1: Islands/sea cross section

We discovered that we could individually control the polymer streams forming each of the “islands” in the cross section, as well as the surrounding streams of “sea” polymer. It occurred to us at that time that by selectively turning on or off any number of these 37 island polymer streams, we could create an enormous number of distinct cross sectional patterns. Figure 2 illustrates just three examples among the more than 100 billion possible patterns. Whereas the islands/sea cross section is a challenging one to form using conventional bicomponent extrusion technology, FIT’s extrusion technology allows us to switch from one of these cross sectional patterns to any other with relative ease.

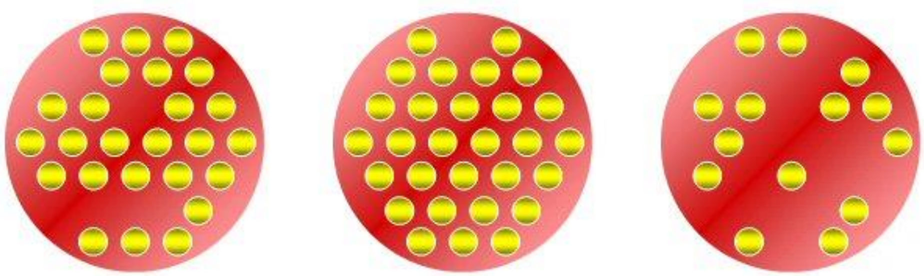

Figure 2: Islands/sea taggant cross sections

So it became apparent that we could make a series of fibers with unique cross sections, and that these fibers could be incorporated into various products as taggants.

Since only a very small quantity of fibers can effectively mark any individual article, the higher cost of producing a large number of patterns nevertheless results in little to no significant effect on the article's ultimate price.

Taggant filament yarns with cross sections like this could be woven or knit into fabrics at one end in every hundred or even one in every thousand ends and still provide a marker that is easily located and which uniquely identifies the fabric's source. Similarly, taggant staple fibers blended with non-taggant fibers at ratios of one percent or less could effectively identify spun yarns or nonwoven fabrics at negligible added cost. Because the taggants is in fiber form, and can be made with polymers substantially similar to the other fibers in the article, it is extremely unobtrusive, even to the extent of being dyed along with the non-taggant fibers. Beyond fabrics, the fibers could be cut relatively short and dispersed in various bulk products. In explosives, for instance, short fibers would be expected to be found much closer to a detonation site than striped plastic pellets. And because few fiber manufacturers are capable of making such cross sections, let alone any would-be counterfeiter who does not control a major fiber manufacturer, the reliability of fiber taggants is very high.

The second generation

Bicomponent fiber taggant technology is viable as described for certain applications, but there are some drawbacks that we've since addressed. For instance, the multiple axes of symmetry make it impossible to tell one pattern from its twin rotated any multiple of 60 degrees, or its mirror image if the fiber's cross section is viewed from the opposite end of the fiber. In addition, even short-cut fibers in some bulk products might be unacceptably obtrusive or even potentially degrade the bulk material's performance. Further, the fiber taggants envisioned above are generally not suitable for use in applications where the taggants is to be ingested, such as foodstuffs and pharmaceuticals.

Our second phase of development with fiber taggants began with an inquiry by a startup firm that wanted to mark corn and beef with taggants that were adhered to the food itself. They proposed slicing our taggant fibers extremely thinly (down to about 20 microns) to produce microscopic disks, and adhering these disks to the foodstuff using an edible adhesive. A machine vision system would scan photomicrographs of the foodstuff, identify the disks and analyze the identifying pattern.

The first innovation required for these applications was to create a fiber from two edible polymers. After much experimentation, we discovered that suitable bicomponent fibers could be produced from polylactic acid (PLA) and a melt-extrudable grade of polyvinyl alcohol (PVOH).

A second innovation refined the cross section. To eliminate ambiguities related to pattern symmetry, we replaced the islands/sea cross section with one having a central shaped island designating proper orientation, and surrounded this central shape with twelve islands that could be turned on or off independently (Fig. 3). The central orientation shape gave this cross section its name.

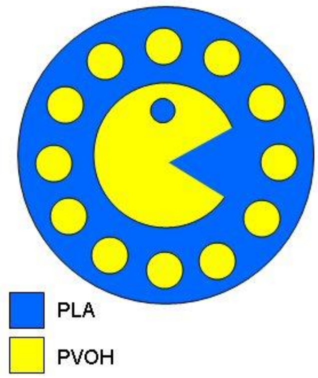

Figure 3: The "Pac-Man" taggant cross section

In this cross section, we've reduced the number of varying features from 37 to 12. So the number of patterns is reduced to 4,096. For many applications, 4,096 patterns is plenty. For others, the solution is to blend two different patterns together to identify the product. Then the number of unique combinations of patterns increases to over 16 million.

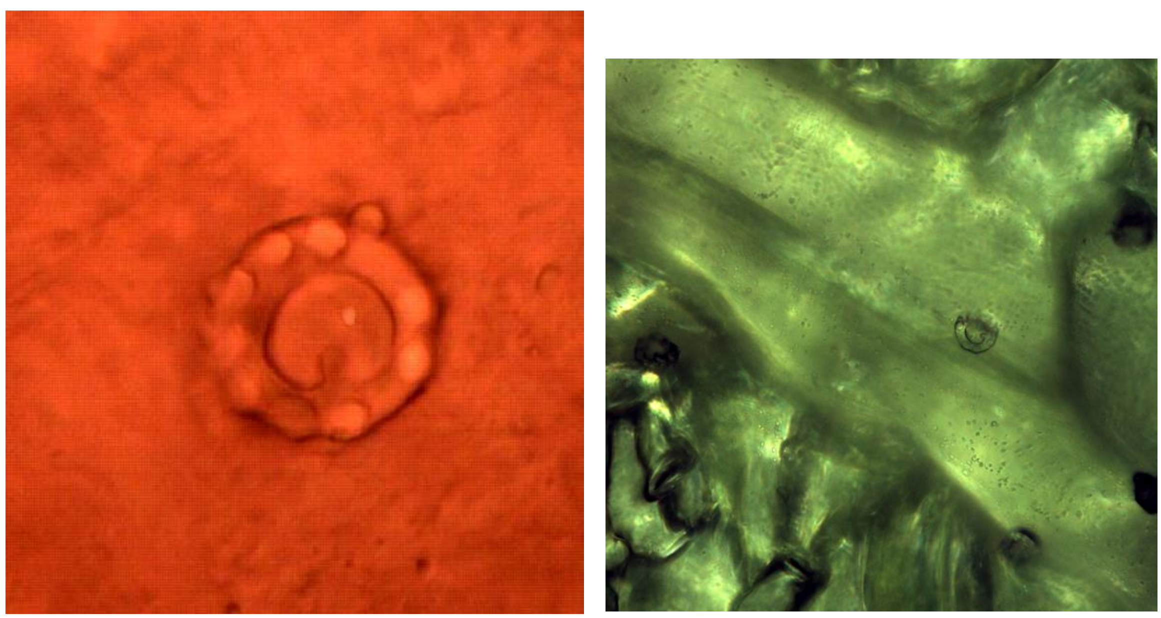

Figure 4: "Pac-Man" taggant on ground beef and spinach

In the PLA/PVOH version of these taggants, both polymers are edible, but in some cases, it may be easier for the machine to detect and read the polymer/air interface than the PLA/PVOH interface. Further, some processes require exposure to water that may soften and remove the PVOH. Removing the PVOH from this cross section would remove the Pac-Man's eye, and we would lose its designation of orientation. To correct this, we devised a third cross section, in which the PVOH can be washed out without losing any information (Fig. 5). The shape formed by this cross section suggests the head of a chicken in a way that should now make clear why it is so-named.

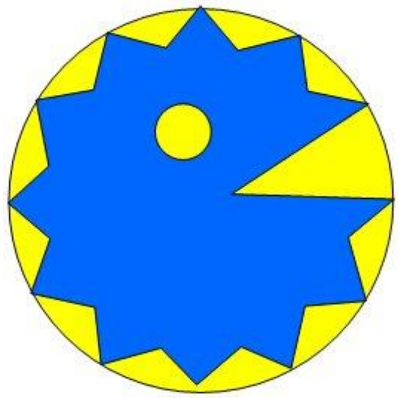

Figure 5: "Chickenhead" taggant cross section

Here, finally, is our superhero. The "eye" and "beak" serve to orient the pattern, and the twelve bumps or notches around the chicken's "head" can be turned on and off independently. The cross section can be made using PLA and PVOH and sliced thin for ingestible applications. If desired, the PVOH can be washed out without losing any identifying information (Fig. 7). It can be made sufficiently inexpensively to have little or no impact on the cost of the product being marked. It can provide precise and reliable identification of the product's source. And the security of this cross section is even greater than that of the islands/sea taggants. That is because this cross section relies on more than merely turning polymer streams on or off, but on the precise shaping of the interface between the two polymers. Such precision is available only using extrusion technology patented by Fiber Innovation Technology[10].

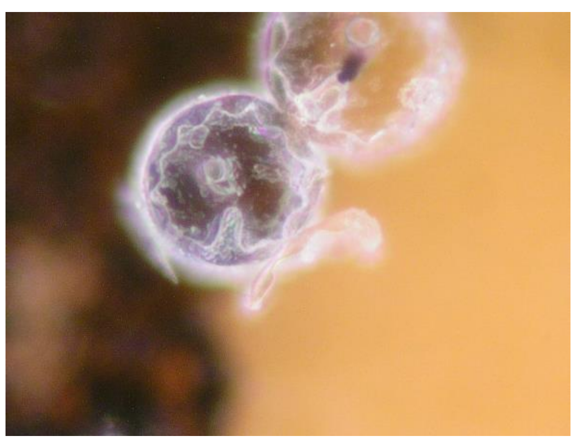

Figure 6: "Chickenhead" taggants on a pharmaceutical capsule

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[10] U.S. Patent no. 6,361,736.

Of course, this cross section can also be made using non-edible polymers for applications demanding different materials properties. Flame-retardant polymers can be used for inclusion with explosives. Related to explosives, it has been proposed to include taggants in some types of fertilizer, since such fertilizers and fuel oil can form an explosive mixture attractive to criminals because of the availability and lack of traceability of the materials. In marking fertilizer, it will be important that these fibers can easily be made using biodegradable materials. For authenticating gemstones, taggant fibers can be made using polymers that resist discoloration. For combating counterfeiting of banknotes and security papers as well as garments or other articles made with fibers, the short-cut fiber, staple fiber, and filament forms further extend the usefulness of bicomponent fiber taggants.

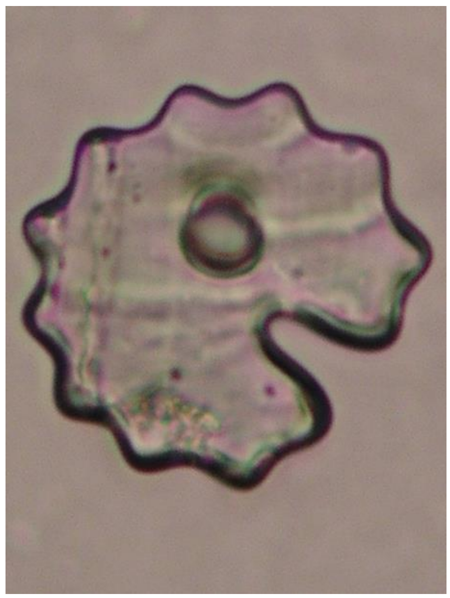

Figure 7: "Chickenhead" taggant with PVOH component removed

No other taggant technology is useful in as broad an array of applications while simultaneously providing a large amount of information, a high degree of inconspicuousness, a relatively low cost impact, and such high barriers to counterfeit production of the taggant itself.

So what has Superman done for <u>you</u> lately?