Using DNA to Prevent Counterfeiting and Product Diversion Applied DNA Sciences, Inc. September 19, 2007 Product Security Session TAPPI PLACE Annual Meeting St. Louis, Missouri

Abstract

Applied DNA Sciences (APDN) provides botanical DNA encryption, embedment and authentication solutions that can help protect companies, governments and consumers from counterfeiting, fraud, piracy, product diversion, identity theft and unauthorized intrusion into physical locations and databases. Our Program provides a secure, accurate and cost-effective means for our potential customers to incorporate our DNA Markers in, and then quickly and reliably authenticate and identify a broad range of items including art and collectible, fine wine, consumer products, pharmaceuticals, digital media, financial instruments, identity cards and other official documents. Having the ability to reliably authenticate and identify counterfeit versions of such items enables companies and governments to detect, deter, interdict and prosecute counterfeiting enterprises and individuals.

Introduction

Counterfeiting, product diversion, piracy, forgery, identity theft, and unauthorized intrusion into physical locations and databases create significant and growing problems to companies in a wide range of industries as well as governments and individuals worldwide. The U.S. Chamber of Commerce reported in 2006 that counterfeiting and piracy cost the U.S. economy between \$200 and \$250 billion per year, was responsible for the loss of 750,000 American jobs and increasingly poses a real threat to consumer health and safety. The World Customs Organization and Interpol estimate that annual global trade in illegitimate goods was roughly \$600 billion in 2004. Overall it is estimated that between 5-10% of global trade is affected by counterfeiting and diversion, equal to hundreds of billions of dollars annually.

Historically, counterfeiting, product diversion and other types of fraud have been combated by embedding various authentication systems and rare and easily distinguishable materials into products, such as radio frequency identification (RFID) devices and banknote thread in packaging, integrated circuit chips and magnetic strips in automatic teller machine cards, holograms on currency, elemental taggants in explosives and radioactivity and rare molecules in crude oil. These techniques are effective but have generally been reverse engineered and replicated by counterfeiters, which limits their usefulness as forensic methods for authentication of the source of products and other items. DNA Markers are as broadly applicable, convenient and inexpensive as existing authentication systems, while being highly resistant to reverse engineering or replication. Either applied independently or to supplement existing systems, DNA Markers offer a forensic level of authentication for a broad range of items providing an additional deterrent in the constant battle against counterfeiting and piracy.

DNA Markers

Every living organism has a unique DNA code that determines the character and composition of its cells. Botanical DNA encryption, embedment and authentication solutions can help protect companies, governments and consumers from counterfeiting, fraud, piracy, product diversion, identity theft and unauthorized intrusion into physical locations and databases. The core technologies of Applied DNA Sciences (APDN) business allow us to use the DNA of everyday plants to mark objects in a unique manner that can only be replicated at great expense, and then identify these objects by detecting the absence or presence of the DNA.

The proprietary program consists of three steps – creating and encapsulating a specific encrypted DNA segment, applying it to a product or other item and detecting the presence or absence of the specific segment.

Creating and Encapsulating DNA

The DNA Markers are botanical DNA segments custom manufactured to identify a particular class of or individual product or item. During the manufacturing process, the naturally occurring botanical DNA segment or segments are taken and rearranged into unique encrypted segments or **chimers** whose sequences are known only to APDN. These sequences are then recorded and stored in a secure database. The DNA is modified, not for its biological relevance, but for its information content and is rendered biologically non-functional during this process. Because DNA is inherently unique and dense with information, only minute amounts of DNA molecules need to be placed on any product to mark and authenticate it.

A patented encapsulation system allows for the application of a protective coating to encrypt DNA chimers, creating DNA Markers that are resistant to heat, organic solvents, chemicals and UV radiation and so can be identified for hundreds of years after being embedded directly or into media applied or attached to the item to be marked.

Embedding DNA

A patented embedment system allows the incorporation of DNA Markers into a broad variety of things. DNA Markers can be directly embedded in products or other items, or otherwise attached by embedding them into media (such as ink, varnish, paint and thread) that is incorporated in or attached to the product or item. DNA Markers can be embedded directly in paper, metal, plastics, stone, ceramic and other materials. DNA Markers can also be embedded onto printed barcodes, RFID tags, optical memory strips, holograms, tamper proof labels and other security devices incorporated into products and other items for various security-related purposes.

DNA Markers can be readily incorporated into inks and coatings which can then be applied directly or on a label that is then affixed to the product or item. DNA Ink is highly durable and degradation resistant. It can be visible (overt) or invisible (covert). Similar media like varnish and paints can also be used. DNA Markers can also be readily incorporated into thread, which can consist of any fabric from cotton to wool and can be used to mark and authenticate products and other items incorporating textiles.

Detecting the Presence or Absence of DNA Markers

Because the portion of DNA in a DNA Marker used to identify the marker is so minute, it cannot be detected unless it is replicated billions of times over, or amplified. This amplification can only be achieved by applying matching strands of DNA, or a primer and PCR techniques to the DNA Marker. The sequence of relevant DNA in a DNA Marker must be known in order to manufacture the primer for that DNA. As a result, the effort required to find, amplify, select and clone the relevant DNA in a DNA Marker would involve such enormous effort and expense that DNA Markers are virtually impossible to copy without the company's proprietary systems.

DNA Encryption Detector pens are custom manufactured to identify DNA Markers, allowing the determination of the presence or absence of these DNA Markers in around one second. When the DNA Encryption Detector Pen comes in contact with the proprietary overt ink on a label or product package, a biochemical reaction triggers a reversible color change from blue to pink and back to blue. Testing of this color change can be repeated between 30 to 50 times. For forensic level authentication, PCR testing kits can product absolute authentication in less than 30 minutes using portable PCR machines.

Proprietary PCR kits allow a sample to be taken from the product or other item to be authenticated and using proprietary primers and PCR technology, determine the sequences of DNA included in the sample and conclude whether it includes a specific DNA Marker. This authentication process provides absolute certainty about the presence or absence of specific types of DNA Markers, resulting in a forensic level of authentication which cannot be found with many other systems.

Conclusion

DNA Markers offer a secure, accurate and cost-effective means of protecting a broad range of products from counterfeiting and piracy. It offers a forensic level of authentication and can be applied to a variety of media and materials either alone or to supplement existing systems. Having the ability to reliably authenticate and identify counterfeit versions of a broad range of items enables companies and governments to detect, deter, interdict and prosecute counterfeiting enterprises and individuals, offers customers and consumers assurance that the products are authentic and adds value to the bottom line by helping to diminish product diversion and counterfeiting. Preventing counterfeiting and piracy protects consumers, increases brand loyalty and reduces revenue losses to theft.



2007 PLACE Conference September 16-20 St Louis, MO

Using DNA to Prevent Counterfeiting and Product Diversion

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Harnessing the power of Nature:

Embedding DNA for product authentication and anticounterfeiting



Enormous market, estimated *to exceed 6% of Global Trade*

(Source: Lehman Brothers)

•Even small market penetrations can be quite significant

•Multiple industry verticals

•Optimize the combination of sale cycle, margin mix and regulation

Benefits of Product Authentication

- **Deter piracy** and **capture sales revenue** lost to counterfeit products.
- *Protect IP, brand value, image:* eliminate supply chain diversion to insure availability only in authorized channels.
- *Improve marketability and customer confidence* by assuring authenticity.
- *Improve consumer safety* by eliminating counterfeit drugs, aircraft, automotive parts...

Why DNA?

- Employ the variability of the biological universe
- Large, Complex DNA's require significant investment (think Human Genome Project) to detect, decode and copy
- Forensic Evidence: Provides absolute proof of authenticity
- Exquisite sensitivity (PCR), robustness, low cost
- Integration into other encryption systems is seamless



DNA is a digital medium for the physical world

DNA Chimers: The New York Times Analogy



DNA Marker Hosts

- Coatings, Inks, Adhesives, Dyes
- Packaging
- Labels / Seals / Films/ Tapes
- Thread / Fabrics / Textiles
- Liquids, Gels, Pastes
- Powders
- Pressed tablets







DNA Science







Customized Genome: unique Plant Chimer or combination of chimers

Stabilize the Amplicon Amplicon, including "decoy" DNA, is embedded in marker host

Forensic Authentication



Forensic ID of Amplicon by Capillary Electrophoresis or Sequencing



Amplify the Amplicon by PCR





Our portfolio of instant detection platforms is growing rapidly

Instant screen for counterfeits with overt marker

Overt, Quick

Screen

DNA Science



Customized Genome:

unique Plant Chimer or

combination of chimers



Stabilize the

Amplicon



Amplicon, including "decoy" DNA, is embedded in marker host

Forensic Authentication



Forensic ID of Amplicon by Capillary Electrophoresis or Sequencing



Amplify the Amplicon by PCR







Reliability of DNA marker under various conditions

Category	Testing Contents	Result
UV energy	Equivalent to 350 years of UV energy accumulation in Denver	Stable
X-Ray	4 times X-Ray exposure by X-Ray scanning machine of airport	Stable
γ-Ray	30 kGy (kilo-Gray) radiation exposure by Gamma-ray sterilization machine	Stable
pH Thermal	pH 1~ 14 over night>250 deg C, >4 hours	Stable

Authentication

Authentication Modalities

- Level 1 Rapid Screening Mechanism if an "instant" authentication measure is desired, any number of conventional screening tools can be integrated with DNA. Holograms, color-changing ink and up-converting phosphors deliver quick and reliable preliminary authentication screening capability.
- Level 2 *DNA-based* Real Time PCR = 5 to 10 minutes - executed with field-deployed equipment, or at technical center
- Level 3 *DNA-based* Forensic = 1 to 2 hours Executed at technical center

Level 1 Quick Screening: DNA-coincident Optical markers



IR Up-converting phosphor for instant detection

Color-changing dye-DNA Adduct

Level 1 Marker Detection: Quick Screen

- Addition of up-converting phosphors (UCP's) to inkjet ink affords the ability to quickly screen packages for presence of a DNA marker – DNA is covalently linked to the up-converting phosphor
- The DNA-UCP marker may be applied via ink-jet as an invisible, covert marker.



• The DNA-UCP might also be applied in traditional ink-jet visible (overt) markers.

Inkjet Ink DNA marker

• *Incorporate a DNA marker into inkjet ink* used to print Primary/Secondary serial label. Use company-specific marks for different classes of products or to control different aspects of the logistic train.



Identification of Target DNA – Molecular Beacon Hybridization



Level 2 DNA Analysis: Identifies Specific Corporate DNA

Real-time PCR (Polymerase Chain Reaction)

- Desktop PCR device
- Can be an "in-field" procedure for track and trace
- No extraction needed
- As fast as 5~10 minutes
- Proprietary "primer kit" for each specific corporate DNA(s)
- If we use 7 chimers out of 100 available per application, we will have 1.6 x 10¹⁰ variations (16 billion) to choose from





Real Time PCR Quantification

Level 2 DNA Analysis: Identifies Specific Corporate DNA

Portable PCR (Polymerase Chain Reaction)

- Hand-held PCR device
- Quick end-point analysis, enabling non-technical users with minimal training to operate the system with confidence
- As fast as 5~10 minutes
- Proprietary "primer kit" for each specific DNA marker



Level 3 DNA Analysis: DNA sequencing for Legal Forensic Analysis

Capillary Electrophoresis

- A lab based procedure
- 1 to 2 hours
- Proprietary "primer kit" for all corporate DNA(s)
- A service by company (certification and self testing possible for large volume clients)



DNA Sequencing

Integrating DNA with other Authentication Platforms

• DNA platforms integrate with RFID's, Holograms, Optical Strips, Specialty Inks and other pre-existing, nonforensic, authentication technologies, and barcodes:





DNA Marker Applications

- Product Components
 - Automobile parts
 - Packaging
- Ingredients
- Consumer & Luxury Goods
 - Apparel, Cosmetics & Toiletries
- Pharmaceuticals
- Currency
- Artwork, antiques
- Documents (Passports, Stock Options, Legal, Financial, etc.)

Translating Science into Product Protection



Some DNA Commercialized Applications

- High Mountain Tea (Chinese Tea)
- Korean Organic Farmers Association
- Dr. Suwelack Skin and Health Care
- Rhodia (Uniquely Jaguar® program)
- Over 600 million DVD's









German Collagen Dressing Label



Your Beauty is Safe with Us.



Every Dr. Suwelack biomatrix product package is protected with a unique DNA marker to ensure user safety and satisfaction.



to learn more, visit www.skin-healthcare.com/certified suwelack

Uniquely Jaguar® by Rhodia



Color change for rapid authenticity verification

Instant detection of *genuine* Jaguar[®] products through a proprietary color reaction



Kosher Quality can be Authenticated by the Consumer or Retailer



Fool-proof 1st Generation Instant Authentication

- Buffer triggers color-changing ink
- Takes 1 second
- Reversible, may be repeated 30-50 times



Package Marking



Packages can be authenticated in the field using machine or pen.

Media IP Security Features



- DNA-embedded, security seal imprint and adhesive
- Overt, tamper-proof, DNA embedded security label with hologram
- Markers on Disc, primary, secondary packaging

botanical dna authentication

• Barcoding with DNA in ink

AUTHENTICATED

DNA

AUTHENTICATED

RFID with Forensic DNA prevents "cloning" of RFID

The 12-Layer Label



- 1. PET Al sputtered foil release label
- 2. Fluorescent red ink turns orange with red laser
- 3. Musical node hologram: shape shift/color change
- 4. 10 concentric circles. Shapes shift when tilted
- 5. X,Y microdots visible under 30X magnification
- 6. Random interference lines
- 7. 4 microprints of 'CHINA AUDIO VIDIO' (sic)
- Shine red laser 30⁰ from top of X and Chinese 'culture' projects on paper 45⁰ below.
- 9. Three circles encoded with Characters '文', '化'.
- 10. Microprint 'CHINA AUDIO VIDIO'
- 11. Machine readable encrypted codes
- 12. DNA embedded in #2 fluorescent ink

The Last Measure Standing



Thank You

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Please remember to turn in your evaluation sheet...