

# In the United States Court of Federal Claims

No. 97-139 C

(Filed April 29, 2004)

(Reissued for Publication May 25, 2004)

\*\*\*\*\*

**PROCHROMA TECHS., INC. &  
PROF'L COLOR SYS., INC.,**

Plaintiffs,

v.

**THE UNITED STATES,**

Defendant, and

**SOUTHERN MILLS, INC., and  
SPRINGS INDUS., INC.,**

Intervenors.

\*\*\*\*\*

\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*  
\*

Patent infringement; 28 U.S.C. §  
1498; process patent; burden of  
proof; preponderance of the  
evidence.

*Arthur L. Lessler*, South River, NJ, counsel of record for plaintiffs.

*B. Frederick Buchan, Jr.*, United States Department of Justice, Commercial Litigation Branch, Civil Division, Washington, DC, counsel of record for defendant, with whom were *John Fargo*, Acting Director, *Gary L. Hausken*, Assistant Director, and *Peter D. Keisler*, Assistant Attorney General.

*Blas P. Arroyo*, Charlotte, NC, counsel of record for intervenor Springs Indus., Inc.

*Stephen R. Risley*, Atlanta, GA, counsel of record for intervenor Southern Mills, Inc.

---

## OPINION

---

**DAMICH**, Chief Judge.

**I. Introduction**

The Court must determine whether the Government (hereinafter “Defendant”) is liable to two companies (hereinafter collectively referred to as “Plaintiffs”), ProChroma Technologies, Inc. (hereinafter “ProChroma”) and Professional Color Systems, Inc. (hereinafter “ProColor”) for patent infringement. Plaintiffs’ claim, which was filed pursuant to the Court’s jurisdiction under 28 U.S.C. § 1498, alleges infringement of United States Patent No. 4,525,168 (also known as “the ‘168 patent,” and “the Kelly patent”) (in the record at JX 1).<sup>1</sup> Plaintiffs contend that Defendant infringed the ‘168 patent by using the services of two government contractors (hereinafter collectively referred to as “the intervenors”). These intervenors are Southern Mills, Inc. (hereinafter “Southern”) and Springs Industries, Inc. (hereinafter “Springs”), who have allegedly infringed the ‘168 patent by using certain processes to dye polyaramid fiber. Parties’ Joint Stipulation Concerning Findings, Witnesses, and Exhibits (hereinafter “Jt. Stip.”) ¶ 1, at B.1.

After careful consideration of the arguments, and for the reasons set forth below, the Court finds that Defendant is not liable for patent infringement under § 1498.

**II. Background**

*A. The ‘168 Patent*

The ‘168 patent, entitled “Method of Treating Polyaramid Fiber,” was issued to the company now known as ProColor on June 25, 1985, with David Kelly listed as the inventor. Jt. Stip. ¶¶ 3-4, at A.1. ProChroma is the beneficial owner of the patent.<sup>2</sup> *Id.* ¶ 7, at A.2-A.3.

The parties agree that the ‘168 patent “describes a process for pretreating polyaramid fibers, including Nomex®<sup>3</sup> fibers (or fabrics made from these fibers), to facilitate subsequent

---

<sup>1</sup> Hereinafter, whenever the Court refers to PX, DX, or JX, it will be referring to numbered exhibits in the record, which were admitted at the request of Plaintiff, Defendant, or both parties, respectively.

<sup>2</sup> The parties do not dispute ProChroma’s beneficial ownership of the ‘168 patent. ProChroma claims this beneficial ownership by virtue of an agreement that was never filed with the United States Patent and Trademark Office (hereinafter “PTO”). Jt. Stip. ¶ 7, at A.2-A.3.

<sup>3</sup> Nomex® is a type of polyaramid fiber, also known as an aramid fiber. Jt. Stip. ¶¶ 6, 8, at B.3. This classification means that Nomex® is “a fiber whose molecular chains have at least 85% of the amide linkages attached directly to two aromatic rings,” which are rings made up of hydrogen and carbon atoms only. *Id.* ¶ 6, at B.3; *Hawley’s Condensed Chemical Dictionary* 91 (rev. by Richard J. Lewis, 14th ed. 2001) (hereinafter “*Hawley’s*”). Nomex® is a registered

dyeing or printing with anionic dyes (*i.e.*, acid dyes) using conventional methods.” *Id.* ¶ 4, at B.2. This dyeing is often carried out in a dye bath, which is a water bath containing all chemicals necessary for the process to be successful. Dyeing can also be accomplished via printing with print pastes. *See id.* ¶ 46, at A.5, ¶ 59, at C.2, ¶ 74A, at C.4.

The ‘168 patent has 11 claims, but Plaintiffs only assert that claims 1, 2, 4, 7, and 8 have been infringed. *Prochroma v. United States*, 46 Fed. Cl. 750, 753 (2000) (in the record at JX 11); Jt. Stip. ¶ 1, at B.1. Claim 1 determines the scope of the patent, as it is the broadest independent claim. *Prochroma*, 46 Fed. Cl. at 753. That claim is limited to the following process: (1) a method of treating polyaramid fiber, (2) that swells the fiber (often by use of a carrier),<sup>4</sup> (3) introduces a dye site substance<sup>5</sup> into the fiber, and (4) shrinks the fiber. JX 1 at 1.3.

The examples in the patent mainly use two molecules, amides and amines, as carriers and dye site substances, respectively. Jt. Stip. ¶ 20A, at B.4, ¶ 22, at B.4-B.5. The difference between these two types of molecules is that they have different structures and therefore react differently with other molecules. Amines are defined as having “the general formula  $RNH_2$ ,  $R_2NH$ , or  $R_3N$ , where R is any alkyl or aryl group.”<sup>6</sup> *Id.* ¶ 37, at B.7 (internal citation omitted). Amides, in contrast, are characterized as having an R group directly bonded to a carbonyl group. A carbonyl group is simply a carbon atom double-bonded to an oxygen atom. Def.’s First Am. Proposed Additional Findings of Fact (hereinafter “DPFF”) ¶ 41, at 15; *see also* Pls.’ Resp. to DPFF ¶ 41, at 29. An amine acts differently than an amide because it has an available pair of electrons located on its nitrogen atom, while an amide does not. This allows amines to accept protons more easily than amides, and thus to react more easily with other molecules. Jt. Stip. ¶ 39, at B.8; DPFF ¶¶ 43-44, at 16; *see also* Pls.’ Resp. to DPFF ¶ 43, at 30-31, ¶ 44, at 31.

---

trademark of E.I. du Pont de Nemours & Co. It is flame resistant and often used in protective clothing. *Id.* ¶ 5, at B.2.

<sup>4</sup> “[S]welling of the polyaramid fiber may be accomplished in any suitable manner.” JX 1 at 1.2. One way to accomplish swelling is through use of a carrier – a substance that “render[s] [a] region [of the fabric] more penetrable by the dye.” Jt. Stip. ¶ 47, at A.5. Another method, and the patent’s “preferred” embodiment, is to use a solvent, which is a substance that can function as a carrier and is also “capable of swelling polyaramid fiber and dissolving the selected amine or other dye site substance.” JX 1 at 1.2-1.3; Jt. Stip. ¶ 50, at A.6.

<sup>5</sup> When the term “dye site substance” is used, it is intended to be shorthand for “a substance capable of forming an ionic bond with an anionic dye,” which is the actual language of the patent. JX 1 at 1.3; *see also* Jt. Stip. ¶ 22, at B.4; Tr. of Trial held Dec. 4-17, 2003 (hereinafter “Tr.”) at 21.

<sup>6</sup> An alkyl group is made up of only hydrogen and carbon atoms, and an aryl group is an alkyl group with a ring-like structure. Jt. Stip. ¶ 37, at B.7 (internal citation omitted); *Hawley’s*, *supra* note 3, at 34, 91.

## B. *History of the Case*

On March 5, 1997, Plaintiffs brought this patent infringement action against the United States under 28 U.S.C. § 1498(a), which states:

Whenever an invention described in and covered by a patent of the United States is used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, the owner's remedy shall be by action against the United States in the United States Court of Federal Claims for the recovery of his reasonable and entire compensation for such use and manufacture.

Plaintiffs allege that the '168 patent has been infringed by processes utilized by intervenors Southern and Springs, who dye polyaramid fabric that is later made into uniforms for the government. Compl. ¶¶ 16-26. The intervenors both use dye baths to dye this fabric to a single color, a process known as base-shade dyeing. *See* Jt. Stip. ¶ 1, at B.1. After the fabric has been base-shade dyed, it is "overprinted," which means that other pigments are "bonded" to the surface of the already-dyed fabric, in this case to create a fabric having a camouflage pattern.<sup>7</sup> *Id.* ¶ 80, at A.6, ¶ 1, at B.1. The fabric is then sent to other entities, where it is used to make uniforms. *See* Jt. Stip. ¶ 1, at B.1. Plaintiffs claim that, during this process, the intervenors have infringed the '168 patent. Therefore, Plaintiffs assert that the United States is liable under § 1498, since the dyed fabric is "manufactured . . . for the United States." 28 U.S.C. § 1498; Compl. ¶ 27.

The Court issued a claim construction opinion in this case on May 30, 2000, which was published at 46 Fed. Cl. 750. In that opinion, the Court made the following conclusions of law: (1) introducing or exposing the polyaramid fiber to an anionic dye before or during pretreatment is within the scope of the '168 patent; (2) one substance can be used both to swell the polyaramid fiber and to act as a dye site substance; and (3) substances other than amines or substituted amines can be used as dye site substances under the '168 patent. *Id.* at 759-61. Then, after a period of extensive discovery, trial was held in December 2003 to determine liability.

### III. *Analysis of the Patent Infringement Claim*

In this opinion, the Court seeks to determine whether the intervenors' processes infringe the '168 patent. To determine if infringement occurred, the Court will examine (1) the burden of proof in this action, and (2) the similarities and differences between the '168 patent and the accused processes.

---

<sup>7</sup> Although both intervenors use dye baths to dye the fabric to a base shade, only Springs does its own overprinting. *See* Jt. Stip. ¶ 119, at B.14. Southern, instead, uses Duro Industries, Inc. to overprint its base-shade-dyed fabric. *Id.* ¶ 120, at B.14.

A. *Plaintiffs have the burden of proof.*

In a cause of action for patent infringement arising under 28 U.S.C. § 1498(a), precedent and the parties agree that Plaintiffs have the burden of proving infringement by a preponderance of the evidence. *Lemelson v. United States*, 752 F.2d 1538, 1547 (Fed. Cir. 1985); *Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 1361 (Fed. Cir. 1983); Tr. at 2744-46.

The preponderance of the evidence standard requires Plaintiffs to convince the Court that it is more likely than not that Defendant infringed the '168 patent. *Ortiz v. Principi*, 274 F.3d 1361, 1365 (Fed. Cir. 2001); *see also* Christopher B. Mueller & Laird C. Kirkpatrick, 1 Federal Evidence § 65 (2d ed. 2003). “[I]t is ‘not enough that mathematically the chances somewhat favor a proposition to be proved,’” but instead Plaintiffs, who have the burden, must *persuade* the court of their position. *Ortiz*, 274 F.3d at 1365 (quoting *Sargent v. Mass. Accident Co.*, 29 N.E.2d 825, 827 (1940)).

B. *Plaintiffs have not proven infringement by a preponderance of the evidence.*

For Plaintiffs to succeed in their patent infringement action against Defendant, they must prove that the intervenors have “literally or equivalently” infringed Claim 1, the broadest claim of the patent, by meeting all four of its limitations. *Cybor Corp. v. FAS Techs., Inc.*, 138 F.3d 1448, 1459 (Fed. Cir. 1998) (en banc). To determine whether the intervenors have infringed Claim 1, “the claim as properly construed must be compared to the accused . . . process.” *Carroll Touch, Inc. v. Electro Mech. Sys., Inc.*, 15 F.3d 1573, 1576 (Fed. Cir. 1993). Therefore, Plaintiff must prove, by a preponderance of the evidence, that each of the intervenors’ processes (1) is a method of treating polyaramid fiber (2) that swells the fiber, (3) introduces a dye site substance into the fiber; and (4) shrinks the fiber. JX 1 at 1.3.

**1. Method of Treating Polyaramid Fiber**

First, Plaintiffs must prove that each of the intervenors uses a “method of treating polyaramid fiber.” JX 1 at 1.3. However, Plaintiffs did not have to present evidence on this matter at trial, since the parties stipulated that Nomex® is “a particular type of polyaramid fiber” that Springs and Southern treat by “dyeing . . . to the background shade.” Jt. Stip. ¶ 5, at B.2, ¶ 59, at C.2; *see also id.* ¶ 74A, at C.4.

**2. Swelling the Fiber**

Second, Plaintiffs must prove that each of the intervenors’ processes “swell[s] the fiber.” JX 1 at 1.3. Since the parties agree that the intervenors’ carriers do indeed swell the fiber, no evidence was necessary on this limitation. Tr. at 85-86.

**3. Introducing a Dye Site Substance**

Next, Plaintiffs must prove that the process used by each of the intervenors “introduc[es] into the swollen fiber a substance capable of forming an ionic bond with an anionic dye,” which the parties refer to as a “dye site substance.” JX 1 at 1.3; *see* Tr. at 21, 74. Although both parties agree that the amide carriers used by the intervenors are not dye site substances,<sup>8</sup> Plaintiffs contend that the carriers undergo a chemical reaction known as amide hydrolysis, in which an amide (such as the Springs or Southern carrier) reacts with water to form an amine and an acid. Pls.’ Proposed Findings of Fact (hereinafter “PPFUF”) ¶ 39, at 18, ¶ 40, at 19; Tr. at 119, 124, 1722-24; *see also* DX 123 at 123.5. Whether this reaction occurs in the intervenors’ processes is important because an amine is considered the “preferred” dye site substance of the ‘168 patent. JX 1 at 1.3.

Plaintiffs have tried to prove that amide hydrolysis happens during the intervenors’ processes by a variety of methods. Experts on both sides have conducted many tests. However, Plaintiffs have not succeeded in meeting their burden of proof because (1) Plaintiffs have not proven that the hydrolysis reaction is possible under the relevant conditions, and (2) the Court finds Plaintiffs’ experimental evidence of hydrolysis unconvincing.

**a) Plaintiffs have not proven that hydrolysis can occur under the conditions of the intervenors’ processes.**

Hydrolysis, as discussed above, is a reaction by which an amide and water form an amine and an acid. PPFUF ¶ 39, at 18; Tr. at 1722-24; *see also* DX 123 at 123.5. The first step of this reaction is protonation of the amide, in which an amide binds to a hydrogen ion (proton)<sup>9</sup> in the water and thereby gains a positive charge.<sup>10</sup> Tr. at 615, 617, 1339, 2392; *see also* DX 123 at 123.5. In the second step, the positively charged amide reacts with water to produce a carboxylic

---

<sup>8</sup> In the early stages of testing, Plaintiffs’ expert Dr. Hall claimed that the amide carriers could act as dye site substances. PX 75 at 75.79, 75.84. At trial, though, he admitted that they could not. Tr. at 865-66.

<sup>9</sup> A brief note is needed on the structure of elements, since the elements hydrogen and nitrogen will be discussed throughout this opinion. Elements are made up of atoms, which are the smallest possible units of an element that retain that element’s properties. *See Hawley’s, supra* note 3, at 98. At the center of an atom is its nucleus, which is made up of positively charged particles called protons, and neutral particles known as neutrons. *Id.* at 806, 934. The nucleus is surrounded by layers of electrons, which are the negatively charged particles of an atom. *Id.* at 436-37. When an atom loses or gains electrons, it becomes an ion. Therefore, when a hydrogen atom, which consists of one proton and one electron, loses its electron to form an ion, all that is left is the proton. *See id.* at 613, 934. As a result, the term “hydrogen ion” will be used interchangeably with the word “proton” in this opinion.

<sup>10</sup> Although there appears to be disagreement as to the timing of the reaction, the Court finds that the steps listed here constitute a general hydrolysis reaction. *See* Part III.B.3.a.i., *infra*.

acid and an amine. Tr. at 615, 617, 2396-97; *see also* DX 123 at 123.5. Finally, the amine protonates, or gains a proton, so that it can ionically bond with a dye molecule.<sup>11</sup> Tr. at 617, 2397.

The parties agree that, in general, extreme conditions are required for amide hydrolysis to occur, since amides are usually very stable molecules under dye bath conditions.<sup>12</sup> *Id.* at 488, 2019. It is also noteworthy that Southern's carrier is described in a joint exhibit as having "Superior Resistance to Hydrolysis"; therefore, it is especially important that extreme conditions exist in Southern's process. JX 14 at 14.2. As a result of the severity of conditions needed to cause amide hydrolysis, disagreement centers on whether the conditions in the intervenors' dye baths<sup>13</sup> meet the "extreme conditions" requirement. Plaintiffs believe that the conditions are sufficiently extreme to support hydrolysis, and they attempt to prove their assertion by presenting evidence on (1) the acidic nature of the intervenors' dye baths, (2) the role of energy in enabling the alleged reaction, and (3) the structure of Southern's carrier. However, after considering the arguments below, the Court is not convinced that hydrolysis is possible under the relevant conditions.

#### i. Acidity of the Dye Baths

Acidic conditions are essential to the hydrolysis reaction, since acidity determines the number of hydrogen ions (protons)<sup>14</sup> available for reaction. Tr. at 907. Defendant, however, asserts that the intervenors' dye baths are not sufficiently acidic to allow the first step of the hydrolysis reaction, protonation of the amide, to occur. *Id.* at 1722-38. This, Defendant says, will prevent the hydrolysis reaction from occurring at all. *Id.* at 1724-25; *see also* DX 123 at 123.5. Plaintiffs' experts, Dr. David M. Hall and Dr. Edward J. Parish, have actually admitted that amide protonation cannot occur under the dye bath conditions, but they state that protonation

---

<sup>11</sup> The parties have stipulated that "[t]he '168 Patent teaches . . . that an assumed dye site substance does not have the capability to ionically bond unless the substance protonates during the dyeing process, *i.e.*, accepts a hydrogen ion from the acid in the dye bath or in a print paste so as to become positively charged." Jt. Stip. ¶ 137, at B.17.

<sup>12</sup> Even Plaintiffs' expert agrees that amides are generally very stable compounds. *See* Tr. at 887.

<sup>13</sup> In addition to arguing that hydrolysis happens in the intervenors' dye baths, Plaintiffs allege that hydrolysis occurs while the fabric is being dried, both after being base-shade dyed and after being overprinted. PX 104 ¶ 166, at 104.17-104.18, 104.26-104.29; Tr. at 647-48. However, as a result of Plaintiffs' dearth of evidence on this issue and disagreement by Defendant's expert Dr. Hodge, the Court is not convinced that hydrolysis occurs during the fabric drying phase of either intervenor's process. *See* DX 15 ¶ 158, at 15.21; Tr. at 2025-27.

<sup>14</sup> *See* note 9, *supra*.

is the first step in only “one method of hydrolysis.” Tr. at 1339; *see also id.* at 886. Neither of their experts, however, has identified for the Court an alternative reaction that does not involve protonation of an amide. *Id.* at 1339. Furthermore, Defendant has a literature reference to support its interpretation of the general hydrolysis reaction, while Plaintiffs have none. *See* DX 123 at 123.5. Therefore, since both parties agree that no protonation occurs in the only type of hydrolysis reaction in evidence, and since Plaintiffs have provided no other credible explanation for how the hydrolysis reaction could happen without protonation, the Court must agree with Defendant that hydrolysis will not occur in the dye baths without protonation of the amide carriers.

Nevertheless, Plaintiffs contend that the intervenors’ dye baths contain acids that “can cause the amide bond to become weaker, and therefore, much easier [sic] subjected to hydrolysis.” Tr. at 472. They assert that, in addition to the acid that is intentionally added to the intervenors’ dye baths, acid enters the baths through the dyes and through acid-interchange reactions. *Id.* at 471-72. However, Plaintiffs have presented little evidence to show that these reactions occur. In fact, Dr. Parish admits that information suggesting that any of the dye bath ingredients significantly affects amide hydrolysis “doesn’t exist in the literature.” *Id.* at 1333-34. He also admits that he has no experimental evidence that the ingredients do affect hydrolysis. *Id.* In contrast, Defendant has presented evidence that the dyes used in the intervenors’ dye baths do not form acids: Defendant’s expert Dr. James D. Hodge made up the dye baths with the appropriate amount of acid and found that addition of the dyes did not make the bath more acidic. *See id.* at 1572-75; *see also* DX 68G; DX 68H. As a result of Plaintiffs’ lack of evidence on this issue and the persuasiveness of Defendant’s evidence, the Court is not convinced that the dye bath ingredients, other than acid, water, and carrier, could affect hydrolysis.

Furthermore, even if the alleged acids are present in the intervenors’ processes, the deciding factor of acidity is the pH, which measures the hydrogen ion concentration available for reaction. PPFUF ¶ 38, at 17; Tr. at 907, 913. The lower the pH value, the more acidic a substance is—below 7 is considered acidic, and above 7 is considered basic, with 7 being neutral. PPFUF ¶ 38, at 17-18; Tr. at 909. The most extreme conditions throughout the intervenors’ processes are present in the dye baths of Springs and Southern, in which the pH values are those stipulated by the parties. Jt. Stip. ¶ 75, at C.4-C.5, ¶ 59, at C.2; Tr. at 1760. Since Dr. Hall admits that “amides are not protonated unless under very low pH around 1.2,” and the Springs and Southern dye baths are significantly less acidic than 1.2, it seems reasonable to conclude that amide hydrolysis cannot occur in the intervenors’ dye baths. Jt. Stip. ¶ 75, at C.4-C.5, ¶ 59, at C.2; Tr. at 1760. Finally, even if addition of the dyes does change the pH of the dye bath, Defendant has presented good evidence that the pH of each dye is higher than 7. As a result, addition of the dyes would tend to make the pH of the dye baths more basic, not more acidic,



meaning that fewer hydrogen ions would be available for reaction. *See* DX 92;<sup>15</sup> Tr. at 2405-06. Therefore, hydrolysis would be even less likely to occur.

In addition to being necessary for protonation of the amide, acidic conditions are required at the end of the hydrolysis reaction for protonation of the amine. Both parties agree that this is necessary before the amine can ionically bond to the dye.<sup>16</sup> Since Plaintiffs have not shown that each dye bath contains the necessary level of acidity to allow ionic bonding to occur, the Court finds that Plaintiffs have not met their burden of proving that the baths are sufficiently acidic to permit hydrolysis.

## ii. *The Role of Energy*

Plaintiffs' expert Dr. Hall contends that microvoids, which are amorphous areas in the Nomex® fiber, provide the necessary energy to encourage hydrolysis in the intervenors' dye baths. Tr. at 629-32; *see* PX 104 ¶¶ 161-62, at 104.16, ¶ 163, at 104.16-104.17, ¶¶ 164-65, at 104.17, 104.26-29. He testified that, "inside the microvoids, [Plaintiffs] have very, very good evidence to show that the energy requirements needed to convert the carrier into a dye-site substance is [sic] present." Tr. at 471. However, this broad statement is not supported by the evidence, as Dr. Hall has admitted that there are no literature references in the record that buttress his statement. *Id.* at 886; *see* PX 104 ¶¶ 161-62, at 104.16, ¶ 163, at 104.16-104.17, ¶¶ 164-65, at 104.17, 104.26-29. In contrast, Defendant's expert Dr. Hodge testified that microvoids do not affect hydrolysis, saying, "[O]ut in the dye bath [the carrier]'s going to have the same hydrogen bonding going on there as would occur in a fabric. So there's really no difference between what's going on in the fabric and what's going in the dye bath itself." Tr. at 2024-25; *see also* DX 15 ¶¶ 152-53, at 15.19. Even without Dr. Hodge's testimony, though, the scant amount of evidence that Plaintiffs have produced in support of their theory is not sufficient to convince this Court that microvoids encourage the hydrolysis reaction.

Plaintiffs also contend that the intervenors' use of jet dyeing machines, which dye within closed chambers, can affect the energy in their base-shade dyeing processes. Tr. at 653-56. Specifically, Plaintiffs claim that, at least in the Springs process, the jet dyeing machine contains high-energy steam that encourages hydrolysis. *Id.* at 655-56. However, as Plaintiffs have presented no convincing evidence that this high-energy steam is produced and affects the

---

<sup>15</sup> DX 92 is a collection of Material Safety Data Sheets (MSDS), which the Occupational Safety and Health Administration (OSHA) requires manufacturers of hazardous substances to provide. *See* 29 C.F.R. § 1910.1200(g). The purpose of these documents is to inform others about the possible dangers of each hazardous substance a manufacturer produces. One of the pieces of data given in an MSDS is the pH of the substance. DX 92 indicates that the orange dye has a pH of 7.8-8.8, the red dye has a pH of 8.5-9.5, and the blue dye has a pH of 9.0-10.0. DX 92 at 92.2, 92.7, 92.11.

<sup>16</sup> *See* note 11 and accompanying text, *supra*.

reaction,<sup>17</sup> the Court is not persuaded that the jet dyeing machine affects the proposed hydrolysis reaction in the dye bath of either intervenor.

iii. *The Structure of Southern's Carrier*

Finally, Plaintiffs claim that the structure of Southern's carrier encourages hydrolysis. In Dr. Hall's testimony, he stated that Southern's carrier is "a strained five unit ring" and that each of the "bond[s] is weaker than if [ ] it [were] on the six-member group," so that each bond is "easier to break." Tr. at 483-85. However, Plaintiffs could not produce evidence in the literature that this extra strain actually exists. *Id.* at 893. Furthermore, Defense expert Dr. Michael E. Wright disagrees with Dr. Hall's contention. *Id.* at 2378-80. Thus, the Court is faced with a "battle of the experts." As a result, the Court turns to the reliability of the expert testimony and, after much consideration, finds Dr. Wright more credible and is ultimately more convinced by his testimony.

Because of the above facts, the Court finds that Plaintiffs have not proven, by a preponderance of the evidence, that conditions were appropriate for amide hydrolysis in either of the intervenors' dyeing processes.

**b) Plaintiffs' experimental results have not convinced the Court that hydrolysis occurs in the intervenors' dye baths.**

As discussed above in Part.III.B.3.a., when amide hydrolysis occurs in a system, it produces an amine. Therefore, Plaintiffs have conducted many tests in an attempt to prove that an amine is produced in the intervenors' dye baths. However, the experimental evidence presented does not convince the Court that the intervenors' carriers react to form dye site substances, and specifically amines, in their base-shade dyeing processes.

i. *Nuclear Magnetic Resonance (NMR) Spectroscopy*

Nuclear Magnetic Resonance spectroscopy (hereinafter "NMR") is an important tool that measures the responses, or magnetic moments, of various nuclei that are placed in a magnetic field and irradiated with frequencies. *See* DX 14 ¶ 12, at 14.7; Tr. at 1151-52, 2384. Two common types of NMR are nitrogen NMR (hereinafter "N-NMR") and proton NMR (hereinafter "P-NMR"). *See* DX 14 ¶ 11, at 14.6-14.7, ¶¶ 12-14, at 14.7. N-NMR uses the nuclei of nitrogen 15 ( $N^{15}$ ) isotopes,<sup>18</sup> while P-NMR uses the nuclei of hydrogen ions (protons).<sup>19</sup> *See id.* ¶ 13, at

---

<sup>17</sup> There is a dearth of information on this theory in Plaintiffs' evidence, and they have only presented two documents in support of it: PX 42, which is simply a diagram of a jet dyeing machine, and PX 48, which is a thermal energy chart prepared by Dr. Hall.

<sup>18</sup> Nitrogen 15 is an isotope, or form, of the element nitrogen. *See Hawley's, supra* note 3, at 633. It is present in 0.37% of naturally occurring nitrogen. *Jt. Stip.* ¶ 109, at A.7; *Hawley's, supra* note 3, at 792. Plaintiffs' expert Dr. Parish refers to  $N^{15}$  as "a minor isotope of naturally

14.7; Tr. at 1151-52. Since either method can be used to help identify an unknown compound, such as the alleged amine involved in this case, researchers may choose to use either P-NMR, like Defendant, or N-NMR, like Plaintiffs. *See* DX 14 ¶ 12, at 14.7, ¶ 34, at 14.17; Tr. at 869-70.

Both parties agree that, in the field of chemistry, P-NMR is the more popular method of NMR. Tr. at 36, 1144. This is because the proton has a strong magnetic moment, while nitrogen has a very weak one. *Id.* at 2385; *see also id.* at 36, 39. Even Dr. Hall agrees that “nitrogen-containing compounds are quite insensitive to the N-NMR method” and that N-NMR “[i]s not the most accurate method.” *Id.* at 868, 870; *see also* DX 94 at 94.1; Tr. at 2390-91.<sup>20</sup> In fact, N-NMR is so insensitive that, in one test, it failed to detect the presence of nitrogen in Plaintiffs’ mixture of Southern’s nitrogen-containing carrier at a concentration that is approximately four times that of the carrier in Southern’s dye bath. PX 73 at 73.5-73.6; *see also* Tr. at 2571-74. Despite this insensitivity, Plaintiffs used N-NMR in most of their testing. *See* Tr. at 869-70. The stated reason for this is that their test substances contained a lot of water, which is not suitable for P-NMR use, and that the substitute for water, deuterium oxide, can change the rate of the hydrolysis reaction.<sup>21</sup> *Id.* at 1145.

When a sample is processed by N-NMR, the machine produces a spectrum, which indicates the presence of nitrogen-containing compounds. The compounds appear as peaks and are plotted in parts per million (hereinafter “ppm”). *See, e.g.*, PX 73 at 73.4; PX 128 ¶ 9, at 128.8. The spectrum can be studied to determine whether the peaks correspond to accepted peak ranges for different molecules. Since “[d]ifferent types of nitrogen w[ill] appear in different frequency ranges,” unknown substances can be tentatively identified by this method. Tr. at 1146; *see also id.* at 2662. For instance, in this case the parties were looking for amides (the carriers) and amines (the alleged dye site substances). It is known that amides will be found on the

---

occurring nitrogen.” Tr. at 1152.

<sup>19</sup> Protons in this sense are actually hydrogen ions, which are hydrogen atoms having a positive charge due to the loss of an electron. *See* note 9, *supra*. The hydrogen ion (proton) is the form of hydrogen most commonly found in nature, as around 99.9% of hydrogen exists in this form. Tr. at 2390.

<sup>20</sup> Dr. Wright has even claimed that P-NMR is 50,000 times more sensitive than N-NMR. *See* Tr. at 2391.

<sup>21</sup> Deuterium oxide is a form of water containing two deuterium atoms and one oxygen atom, instead of the usual two hydrogen atoms and one oxygen atom. *See Hawley’s, supra* note 3, at 340, 560. Since a deuterium atom contains one neutron and one proton, as opposed to a hydrogen atom, which consists of one proton only, deuterium oxide is often referred to as “heavy water.” *See id.* at 339. Defendant used deuterium oxide to perform most of its NMR tests. The Court does not need to determine whether deuterium oxide actually changes the rate of hydrolysis, however, because Plaintiffs, not Defendant, have the burden of proof.

spectrum between appropriately -230 and -250, while protonated amines should be found in the range of -320 through -355. *Id.* at 1147. Therefore, if signals are found in one of these areas, there is a chance that the relevant substance is present. However, even Plaintiffs admit that NMR results do not present a definitive answer as to the identity of an unknown compound. *Id.* at 1250, 1253, 1263-64.

Plaintiffs also admit that another disadvantage to using N-NMR technology is that the signal-to-noise ratio for N-NMR is much lower than for P-NMR. PX 128 ¶ 20, at 128.14. This makes it much more difficult to distinguish between noise and a true signal. For example, in one N-NMR spectrum of a sample known to contain the Southern amide, the noise had a similar appearance to the peak. *See id.* at 128.75. This, Defendant contends, is a significant problem in Plaintiffs' tests. However, Defendant does admit that, by scanning the sample repeatedly, the signal-to-noise ratio can be improved. Tr. at 2659-60. But, even though Plaintiffs often ran their samples for a high number of scans, noise was present in many of Plaintiffs' spectra. *See*, Part II.B.3.b.iii., *infra*.

In light of the evidence presented above, by both Plaintiffs and Defendant, the Court finds that there are myriad disadvantages to N-NMR testing. The Court will take this factor into account when weighing the credibility of Plaintiffs' test results.

#### ii. *Tests on Southern's Carrier*

In one of Dr. Hall's experiments, he tested for hydrolysis by heating Southern's carrier and acid, first at 100° C and then at 150° C, each time for 20 minutes. *See* PX 73 at 73.2. Dr. Hall claims that he found the Southern amine after heating this mixture at 150° C, but not when he heated it at 100° C. *Id.*; *see also id.* at 73.7-73.8. From these tests, Dr. Hall concluded that hydrolysis of Southern's carrier occurs "at a temperature between 100°-150° C." *Id.* at 73.2.

However, these tests do not support Plaintiffs' position that hydrolysis occurs in Southern's dye bath, because the conditions of Dr. Hall's tests do not correspond to the conditions of Southern's bath. Specifically, Dr. Hall's tests were heated at much higher temperatures than the stipulated temperature for Southern's bath, and the tests were done under much more acidic conditions than those present in Southern's dye bath. Tr. at 880, 2650; Jt. Stip. ¶ 59, at C.2. The temperature difference would have significantly affected the reaction, since the parties agree that, for every 10 degrees the temperature is increased, the reaction will happen two times more quickly. Tr. at 2651; PX 172 at 172.4. Therefore, any hydrolysis reaction that would have occurred in Dr. Hall's mixture would have occurred more than 60 times more quickly when the mixture was heated at 150° C. Thus, even if hydrolysis occurred in Dr. Hall's experiment, it would not necessarily occur in Southern's dye bath.

Dr. Hall, however, claims that the temperature difference was irrelevant because Southern's dye bath is heated longer than the mixture in his tests and because there was no "other assistance," such as microvoids, to encourage the reaction. Tr. at 691-92, 879-80. However, the Court finds Dr. Hall's testimony unconvincing, because he has failed to provide the reasoning

behind his theory that the additional time in the dye bath could counteract the effects of the higher temperature and increased acidity. Furthermore, the Court has already found that Plaintiffs have not met their burden of showing that the alleged “other assistance” actually occurs. *See* Part III.B.3.a., *supra*. Thus, the Court finds that Plaintiffs have not met their burden for this series of tests, since they did not demonstrate that hydrolysis can occur under conditions similar to those of Southern’s dye bath.

iii. *Dye Bath Tests for Springs and Southern*

In another set of experiments, Dr. Hall and Dr. Parish tested whether hydrolysis would occur in dye baths intended to duplicate those of the intervenors. Tr. at 686; *see* PX 75 at 75.55-75.59. After heating these baths, Dr. Hall found “an oily precipitate in each,” which he claims was each intervenor’s amine. Tr. at 691. However, Plaintiffs admit to making errors in the preparation of the simulated dye baths. First, they admit that too much acid was used in the simulated Springs dye bath, as a result of Dr. Hall’s misinterpretation of the units of acid. *Id.* at 2697, 2702; *see also id.* at 970-77, 2702; *compare* PX 82 at 82.1 with PX 130. Second, the record shows that, while preparing Southern’s simulated dye bath, Plaintiffs did not use the correct amount of dyes. *See* Tr. at 2068-69; *compare* PX 130 with JX 13 at 13.2. Although there has been disagreement over the relevance of these mistakes to hydrolysis, the Court finds that these significant misinterpretations affect the credibility of Plaintiffs’ experts, and thus the Court will consider these problems when determining the reliability of Plaintiffs’ test results. *See, e.g.,* Tr. at 2697.

Furthermore, Defendant has many criticisms of Dr. Parish’s interpretation of this data. First, when Defendant cross-examined Dr. Parish about his prior experience with N-NMR, Dr. Parish admitted that he had no such experience, although he added that, “the principles are the same with other types of NMR.” *Id.* at 1246-48. Second, Defendant raised the issue of a mechanical problem with Plaintiffs’ N-NMR machine, in the context of a standard ammonium hydroxide spectrum. *See* DX 324 at 324.5, DX 325 at 325.5. In this spectrum, there is a pattern of peaks in the accepted range for protonated amines. Tr. at 1267-68. But, since Dr. Parish knew that the only substance in his sample was ammonium hydroxide, he deemed this pattern noise. *See id.* at 1268-71. However, Dr. Parish had said in his deposition that, if he had not known the contents of the ammonium hydroxide sample, he would have thought that there was only a 50/50 chance that he had found ammonium hydroxide, versus protonated amine. *See id.* Furthermore, Dr. Parish decided that a pattern similar to the so-called “noise” in the ammonium hydroxide standard was a *protonated amine* when he knew that his sample included heated Springs or Southern dye bath. *See* DX 324 at 324.3-324.4; DX 325 at 325.3-325.4.<sup>22</sup> In contrast, when this ammonium hydroxide standard (DX 324.5) is compared to an ammonium hydroxide standard that Plaintiffs took on a newer N-NMR machine with a better signal-to-noise ratio (PX 144.5), no pattern was observed in the area in which a protonated amine would be found. Tr. at 1274-76.

---

<sup>22</sup> These four exhibits also appear in Plaintiffs’ exhibits. The exhibits are duplicated as follows: DX 324.3 equals PX 194 fig.5; DX 324.4 is the same as PX 194 fig.7 and PX 75.56; DX 325.3 is also PX 204 fig.6; and DX 325.4 also appears at PX 204 fig.8 and PX 75.59.

This suggests that the N-NMR machine Plaintiffs used for their dye bath tests had a serious noise problem, which was not taken into consideration by Dr. Parish when he interpreted the resulting spectra. Therefore, the Court has serious doubt as to the validity of Plaintiffs' N-NMR data for this set of experiments.

As a result of the apparent mechanical problems with Plaintiffs' N-NMR machine and the mistakes made by Plaintiffs' experts, most of which Plaintiffs admit occurred, Plaintiffs have not convinced the Court that these tests are reliable.

*iv. Overdyeing Tests on Springs and Southern Fabric*

Drs. Hall and Parish also carried out overdyeing experiments on samples of Springs and Southern fabric that had already been base-shade dyed and overprinted. PX 75 at 75.71-75.75; Tr. at 718. In these tests, the experts dyed the fabric again, and observed that the fabric from both intervenors absorbed the dye. See PX 90; PX 91; PX 92; PX 103A; PX 103B. They then tested the ability of the dye to stay in the fabric by using the 3A washfastness test. In that test, fabric is washed many times to see if the dye stays in the fabric. If a high color change rating occurs, it can be concluded that most of the dye was retained in the fabric. PX 89 at 89.1, 89.3. Since the fabric used by Springs and Southern did achieve this high color change rating, Plaintiffs contend that dye site substances are created during the intervenors' processes, and that the fabric kept its color because the dyes bonded with these available dye sites. Tr. at 724; see also PX 75 at 75.71-75.75; PX 95 at 95.3.<sup>23</sup> However, Plaintiffs have not provided the Court with sufficient evidence to find that a dye site substance is present because, although they have shown that the dyes were retained in the fabric, they have not shown that ionic bonding to a dye site substance was the cause of this retention. In essence, Plaintiffs have failed to "adduce evidence that the Government actually . . . practiced the precise methods claimed." *Lemelson*, 752 F.2d at 1548.

*v. Extraction Tests on Springs Fabric*

Dr. Hall decided to perform one more series of tests to assess the possible presence of dye site substances in the intervenors' already-dyed fabric. Although he was unable to obtain samples of Southern fabric, he did secure a set of Springs fabric samples. See Tr. at 52. With these samples, Plaintiffs performed extraction tests, consisting of two sets of extractions, P-NMR testing, and a gas chromatography/mass spectrometry (GC/MS) test. See PX 148 ¶ 1, at 148.3; PX 155 ¶ 3, at 155.3. After conducting the full range of extraction tests on Springs fabric, Plaintiffs contend that they have demonstrated the presence of a dye site substance in the dye bath. PX 148 ¶ 22, at 148.12; PX 155 ¶ 6, at 155.5. The Court disagrees.

*(a) Extraction from Fabric*

---

<sup>23</sup> PX 95 is the official 3A test report for the Springs fabric. However, no corresponding report is in the evidence for the Southern fabric.

In preparation for these tests, Dr. Hall needed to obtain an aqueous solution. To get such a solution, Dr. Hall heated the Springs fabric in an oil bath with a temperature of 260° F. for 2.5-3 hours. PX 119 at 119.4. This process was repeated twice. *Id.* Next, Dr. Hall used the solvent dimethyl sulfoxide (hereinafter “DMSO”) to extract certain materials, including the alleged amine, from the Springs fabric. *Id.*

However, Defendant disagrees with Dr. Hall’s extraction methods, asserting that DMSO was not an appropriate solvent. Tr. at 2072. Defendant states that DMSO can act as a solvent for, and therefore actually dissolve, Nomex®. It also asserts that there is a possibility that DMSO can facilitate other chemical reactions within the system. *Id.* at 979-980; *see also* DX 131 at 131.3-131.4. Although the Court makes no determination on the effects of DMSO, Plaintiffs’ choice of solvent causes doubts to arise.

#### (b) *Preparation of Samples for Testing*

After Dr. Hall performed the initial set of extractions, he gave the extraction fluid to Dr. Parish, who added a saturated salt solution. PX 148 ¶ 9, at 148.6. The extraction fluid was then separated, so that part could be used for NMR testing and the rest could be used for testing by GC/MS. *Id.*

For the extract that was destined for NMR testing, Dr. Parish performed a second set of extractions with benzene and then deuterated benzene. Next, Dr. Parish made the extract basic and extracted it with deuterated benzene and then deuterated water. *Id.* Dr. Parish’s goal was to remove any water, so that he could study the extract using P-NMR analysis.<sup>24</sup> Tr. at 1183-84.

For the extract that would be used for GC/MS analysis, Dr. Parish also performed a second series of extractions, this time using pentane. PX 148 ¶ 12, at 148.7. However, he soon discovered that pentane was not appropriate for this experiment; therefore, the extract was processed to remove the pentane, and the solvent was switched to nonane. *Id.* ¶¶ 13-14, at 148.8. Dr. Parish then carried out his GC/MS testing, but, upon getting results that were “inconclusive,” he asserted that the pentane removal must have also removed the alleged amine. *Id.* ¶¶ 23-24, at 148.12; *see also* PX 155. As a result, Dr. Parish extracted a new sample of Dr. Hall’s extract with nonane alone to prepare the sample for GC/MS testing. PX 155 ¶ 3, at 155.3.

#### (c) *P-NMR Studies of the Extraction Fluid*

The first series of tests that Dr. Parish ran on the extract sample was a P-NMR analysis.

---

<sup>24</sup> *See* Part III.B.3.b.i., *supra* (where Plaintiffs state that problems can occur when water is used in P-NMR studies).

See PX 148 ¶ 16, at 148.9. Dr. Parish prepared and tested a standard of the Springs amine and a control from the undyed Springs fabric,<sup>25</sup> and then tested the extract itself. *See id.* Dr. Parish claims that, from the extract's P-NMR spectrum, he was able to identify the two characteristic peaks of the Springs amine. Tr. at 1188; *see also* PX 148 at 148.32-148.37. However, certain faults appear in Dr. Parish's results. First, upon Dr. Parish's own admission, he had to magnify the results twice to get a spectrum that showed good resolution of the peaks. PX 148 ¶ 17, at 148.9-148.10. In fact, when reviewing the initial, broadest spectrum, no peaks whatsoever are observable. *Id.* at 148.32. Second, Dr. Wright asserts that the peaks observed by Dr. Parish are indicative of substances other than the Springs amine, since they are fairly common peaks. Tr. at 2619-21; *see also* DX 20 at 20.27. As a result, Dr. Wright testified that the extract could not be called the Springs amine until the results were confirmed by further testing, such as by GC/MS. Tr. at 2621.

The Court agrees with Dr. Wright. Although the peaks in Plaintiffs' P-NMR spectra could be indicative of the Springs amine, the results of an NMR process only focus on the magnetic, and not the chemical, characteristics of a substance. *See id.* at 2619; Part III.B.3.b.i. Therefore, the Court finds that NMR results alone are not sufficient to prove that the Springs amine was present in Dr. Parish's extract.

(d) *GC/MS of the Extraction Fluid*

After conducting his P-NMR analysis, Dr. Parish tested his sample using GC/MS, which is actually a combination of two tests. The first part, gas chromatography, is accomplished by injecting a sample into a gas chromatograph. The sample is then carried through a column by a gas and separated into different components based on boiling point. Tr. at 1190, 2622. One compound will generally emerge from the apparatus at a different time than another. This amount of time is known as its "retention time." *Id.* at 2625. Therefore, once a sample is processed by a gas chromatograph, its retention time can be compared with standard retention times of other substances. If the time for the sample matches that of a known standard, then there is a chance that the sample and the standard are the same compound. *Id.* at 1191.

Dr. Parish ran this type of gas chromatography test on the extraction fluid from the Springs fabric. After studying the results, Dr. Parish alleges that he has found the Springs amine, based on the similar retention times for the extract and the Springs amine standard. *Id.* at 1194; PX 199 at 199.1. However, since even Dr. Parish admits that different compounds can emerge from the apparatus at the same time, the GC test is not definitive. *See* Tr. at 1294-95, 2625-26. Therefore, Dr. Parish continued to the second step of GC/MS: mass spectroscopy.

Mass spectroscopy is a very important test because, as Dr. Parish says, "Every organic molecule has got a characteristic fingerprint pattern in the mass spectrometer, and so you try to compare a standard with what you think is the same compound. If they match up reasonably

---

<sup>25</sup> Defendant's expert Dr. Wright, however, does not even believe that Plaintiffs used an appropriate control, since carrier was not included. Tr. at 2616.



well, that's a good indication that you've got that compound." *Id.* at 1190-91. During mass spectroscopy, a small portion of the sample flows directly from the gas chromatograph into a vacuum chamber, where the compounds break apart into different ions. *Id.* at 1190, 2623. Once the ions have exited the chamber, the spectrometer produces a chart that "displays 'peaks' above a baseline at particular locations that are characteristic" of each fragment contained in the sample. Jt. Stip. ¶ 90, at B.13. Each fragment represents the molecular weight of its corresponding ion, and all of these fragments together form a fragmentation pattern, which is presented on a spectrogram. Tr. at 1190, 1302; *see also id.* at 2624-26.

Plaintiffs allege that the spectrogram of Dr. Parish's extract corresponds to the standard spectrogram<sup>26</sup> for the Springs amine. However, the two are not similar enough that one could say that they represent the same "fingerprint." *See* PX 148.43A/PX 156.5B. Most of the differences arise because some of the standard peaks are not present in the sample, while other peaks are present in the sample, but not in the standard. *See id.*; *see also* Tr. at 1317-19. For example, there are no peaks in the sample's spectrogram corresponding to the three fragments<sup>27</sup> that Dr. Wright classifies as the peaks that "have to be there" before the sample can be identified as the Springs amine. Tr. at 2630-31; *see also* PX 156 at 156.5 fig.3. Even Dr. Parish admits that these three fragments, along with the fragment at 44, are the most concentrated fragments of the Springs amine. *See* Tr. at 1314. Furthermore, the extract sample shows a peak at 86, which would not be possible if the substance was the Springs amine, because the total mass weight of the Springs amine is less than 86. *Id.* at 2075; *see* PX 156 at 156.5 fig.3; *see also* Tr. at 1315.

Dr. Parish tries to explain these discrepancies by saying that, since the sample contained only a small amount of the alleged amine, the signal was weak and not all of the peaks could be detected. Tr. at 1195. However, this does not explain why peaks were detected that are not in the standard for the Springs amine. *See* PX 148.43A/PX 156.5B. Dr. Parish also claims that some of the erroneous peaks, the ones that are different from the standard by one mass unit,<sup>28</sup> can be caused by drift due to the calibration of the machine. Tr. at 1320. The Court, however, need not decide this issue because, even if shifting of one unit occurred for some of the peaks in the extract spectrum, the largest peak, which represents the most concentrated fragment, would still

---

<sup>26</sup> The "standard" discussed in this section was created by the National Institute of Standards (hereinafter "NIST"). The first standard Plaintiffs produced did not match the NIST standard, and in fact more closely matched the spectrogram of the extract. Plaintiffs' replacement standard, however, is similar to the NIST standard. *Compare* PX 148.43A/PX 156.5A (showing the NIST standard, Plaintiffs' original standard, and the extract's spectrogram) *with* PX 148.43A/PX 157A (showing the NIST standard and Plaintiffs' replacement standard).

<sup>27</sup> Although it is possible that Plaintiffs' sample contained one of these peaks, the portion of the spectrogram that shows values below 40 was not present in Plaintiffs' spectrogram. As a result, the Court cannot make a determination that the peak was there. *See* Tr. at 1323-26; PX 156 at 156.5 fig.3.

<sup>28</sup> *See* PX 156 at 156.5 fig.3.

be at least three units away from the nearest significant peak for the Springs amine standard. *See* PX 148.43A/PX 156.5B.

As a result of the unconvincing nature of Plaintiffs' results, this Court does not believe that Plaintiffs' extraction tests have proven that a dye site substance is produced in the Springs process. In addition, the credibility of Plaintiffs' experts was damaged when they failed to use a function of the spectrometer that compares the test sample results to recognized standards and gives the likely identity of the sample. If Plaintiffs had used this feature and gotten positive results, this could have been good evidence of the presence of the Springs amine. Tr. at 1326-27.

Furthermore, the Court has decided that Plaintiffs have not met their burden of proving that hydrolysis occurred in the intervenors' processes.<sup>29</sup> And, in light of the conflicting evidence regarding the structure of the different molecules involved and the types of forces that could keep the dye molecules in the fabric, Plaintiffs also have not convinced the Court that no method other than ionic bonding could keep the acid dyes in the intervenors' fabric. *See, e.g.*, PX 37A; 41A; DX 100; Tr. at 952-53.

Therefore, the Court finds that Plaintiffs have not met their burden of proof and thus Defendant cannot be held liable for the alleged infringement of the '168 patent. As counsel for Plaintiffs stated on the last day of trial, "If we didn't convince Your Honor that a dye site substance was in the fabric, that would be the end of it." Tr. at 2745. Unfortunately for Plaintiffs, that is the end of it, because Defendant cannot be held liable where Plaintiffs have failed to meet their burden of proving infringement by a preponderance of the evidence.

#### **4. Shrinking the Fiber**

Finally, the Court will comment on whether Plaintiffs have proven that each of the intervenors' processes "shrink[s] the fiber so as to incorporate said [dye site] substance into the fiber." JX 1 at 1.3. Since the Court has determined that no dye site substance is present in the intervenors' processes, the processes obviously do not "incorporate said substance into the fiber." *Id.*; *see also* Part III.B.3., *supra*. On the other hand, Defendant has conceded that "shrinking does occur," although it also alleges that "the fiber is not shrunk to the degree that it could retain die [sic] site substances if there were any within the fiber, and it doesn't prevent ingress or egress of the dye molecules." Tr. at 87-88. Even Plaintiffs agree that only partial drying of the fabric occurs, although they fail to specify the extent of that drying. *Id.* at 111.

In Plaintiffs' opening remarks, counsel asserted that "the tests show that . . . when dried the fiber [sic] shrunk [sic] nearly back to where they started from." *Id.* at 54-55. However,

---

<sup>29</sup> Plaintiffs claim that two other tests could have been done: (1) an isotope test to show the dyeing mechanism in the intervenors' processes; and (2) a printing test done in the absence of acid. Tr. at 826; Pls.' Mem. of Fact & Law ¶ 20, at 11-13, ¶ 48, at 26. Although Plaintiffs argue that these tests would have been "definitive," Plaintiffs have the burden of proof in this action, and it was thus their responsibility to ensure that any "definitive" tests were done.

Plaintiffs have failed to present evidence sufficient to support this initial statement. In fact, Plaintiffs' one piece of experimental evidence is seriously flawed. In that test, Plaintiffs measured Nomex® fibers, put the fabric through a simulated version of each intervenor's base-shade-dyeing process, and dried the fabric. *Id.* at 713-15; *see also* PX 75 at 75.61-75.62, 75.66-75.67. Dr. Hall then measured the fibers again, using test method 2130 from the American Society of Testing Materials (ASTM). *Tr.* at 714-15; *see also* PX 94; PX 100. He claims that his results show that shrinkage of the fibers occurred. *Tr.* at 715; *see also* PX 75 at 75.62, 75.67. ASTM 2130, however, was only designed to measure the diameters of "any fibers having a round cross section." PX 100 at 100.1 n.1. Although Dr. Hall concedes that Nomex® fibers are not round, but instead "flat," he claims that "instead of measuring diameter, we would measure width, and we could get the same results." *Tr.* at 716.

Dr. Hodge disagrees with Dr. Hall, asserting that the reason that ASTM 2130 is only used to measure round fibers is that, for a round cross-section, "the diameter is the same no matter which way it appears to you." *Id.* at 2042-43; *see also* DX 13 at 13.74. The Court agrees with Dr. Hodge's logic, since people measuring these "flat" Nomex® fibers would not know whether they were measuring the width or the length, which are two *different* measurements in a non-round cross-section. This conclusion is supported by the high standard deviation, or spread, that Plaintiffs found when studying their measurements. *See* PX 94 at 94.13; *see also* *Tr.* at 2045-46; B.S. Everitt, *The Cambridge Dictionary of Statistics* 360 (2d ed. 2002). In fact, even Dr. Hall admits that there was "some probable scatter" in his results. *Tr.* at 931-32 .

Furthermore, Plaintiffs introduced a possible form of error by using Nomex® type 450 fabric, which contains carbon core and carbonyl fibers, in addition to Nomex® fibers. *See* PX 75 at 75.61, 75.66; *Tr.* at 714, 2046. The presence of these other fibers makes it difficult for the Court to believe that only Nomex® fibers were measured and factored into Plaintiffs' conclusions. As a result of this and of the use of an inappropriate testing procedure, the Court finds that Plaintiffs' measurement test results are meaningless and are not good evidence in this case.

Although there is insufficient evidence for the Court to decide whether shrinkage actually occurs in the intervenors' processes, it was incumbent upon Plaintiffs to prove shrinkage by a preponderance of the evidence, which they have not done. Therefore, Plaintiffs have not met their burden of proof on this final limitation of Claim 1.

#### **IV. Conclusion**

Because Plaintiffs have been unable to convince the Court, by a preponderance of the evidence, that either intervenor has infringed claim 1, 2, 4, 7, or 8 of the '168 patent, the Court finds that Defendant is not liable for patent infringement. Consequently, it is unnecessary to

consider further arguments, and the Clerk's Office is instructed to enter judgment for Defendant.<sup>30</sup>

---

EDWARD J. DAMICH  
Chief Judge

---

<sup>30</sup> This document was reissued for publication on May 25, 2004, pursuant to a Joint Report filed by the parties, dated May 14, 2004. The Joint Report stated that the opinion, originally filed under seal, could be published with various minor changes, which have been made.