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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte STEFANIA POLIZU, PHILIPPE POULIN,
OUMAROU SAVADOGO and L'HOCINE YAHIA

Appeal 2015-005532
Application 12/233,336[1]
Technology Center 1600

Before ULRIKE W. JENKS, RICHARD J. SMITH and DAVID COTTA, *Administrative Patent Judges*.

COTTA, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134 involving claims to a biocompatible carbon nanotube-based fiber. The Examiner rejected the claims on appeal as obvious under 35 U.S.C. § 103(a).

We affirm.

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[1] According to Appellants, the real parties in interest are the inventors, Stefania Polizu, Philippe Poulin, Oumarou Savadogo, and L'Hocine Yahia. App. Br. 1.

STATEMENT OF THE CASE

Claims 1–8 are on appeal. Claim 1 is illustrative and reads as follows:

> 1. A biocompatible carbon nanotube-based fiber comprising:
>
> a) at least one carbon nanotube;
>
> b) a nanoparticle of a biodegradable copolymer; and
>
> c) a coagulating polymer matrix,
>
> wherein the at least one carbon nanotube and the nanoparticle of a biodegradable copolymer comprise a binary colloidal mixture dispersed within said matrix and wherein the surface of said fiber is capable of stimulating and sustaining cell proliferation.

The Examiner rejected the claims under 35 U.S.C. § 103(a) as unpatentable over the combination of Polizu,[2] Smalley,[3] Ameer,[4] and Liu.[5]

FINDINGS OF FACT

1. Polizu discloses: "In our preliminary work we synthesized CNTs [carbon nanotubes] based fibers for medical applications. This new hybrid system combines polyvinyl alcohol (PVA) with CNTs and polylactic-co-glycolic acid (PLGA), a biodegradable copolymer. The surface properties of this material are investigated in order to guarantee a biocompatible

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[2] Polizu et al., *Nanoscale Surface of Carbon Nanotube Fibers for Medical Applications: Structure and Chemistry Revealed by TOF-SIMS Analysis,* 252 APPLIED SURFACE SCIENCE 6750–53 (2006) ("Polizu").

[3] Smalley et al., US Patent Publication No. 2004/0040834 A1, published Mar. 4, 2004 ("Smalley").

[4] Ameer et al., US Patent Publication No. 2007/0071790 A1, published Mar. 29, 2007 ("Ameer").

[5] Liu, *Modifications of Carbon Nanotubes with Polymers,* 41 EUROPEAN POLYMER JOURNAL 2693–03 (2005) ("Liu").

response." Polizu Abstract.

2. Polizu discloses: "It is noteworthy that the effectiveness of CNT in hybrid materials strongly depends on the ability to disperse the nanotubes homogenously through the matrix while maintaining their integrity and ensure bonding between components." *Id.* at 6750.

3. Ameer discloses: "[A] composition comprising a biodegradable elastomeric polymeric component and a biodegradable polymeric nano-structure. . . . Preferably, the biodegradable polymer is fabricated into a nanostructure such as a nanofiber, a nanoparticle, or the like." Ameer ¶ 10.

4. Ameer discloses: "[n]anocomposites were fabricated with either 5% (w/w) or 10% (w/w) PLGA nanoparticles." *Id.* at ¶ 93. Ameer further discloses "[n]anoparticles added to the PDC matrix act as additional crosslink points and increase the strength and stiffness (Young's modulus) while decreasing the elongation at break. . . . A statistically significant difference was found when comparing the PDC control without nanoparticles to the PDC-PLGA nanocomposites, indicating that the strength and stiffness could be increased by incorporating nanoparticles." *Id.* at ¶ 94.

5. Ameer discloses: "The PLGA in solvent mixture was added dropwise to the PVA in water solution . . ." *Id.* at ¶ 79.

6. Smalley discloses:

> In one embodiment, the single-wall carbon nanotubes are first dispersed in a fluid, such as an aqueous system containing a molecule, compound or polymer capable of wrapping, encapsulating or otherwise isolating the nanotubes from each other. With vigorous agitation and mixing, the nanotubes are dispersed in the aqueous system as individual carbon nanotubes and protected from reaggregation with a coating or wrapping that does not perturb the electronic properties of the nanotubes.

Smalley ¶ 57.

7. Smalley discloses "non-perturbing coatings that could be used include polymers, such as . . . polyvinyl alcohol . . . The polymers can wrap around the nanotubes and render the nanotubes soluble in water and other compatible solvents. Moreover, the polymer wrapping or coating can be removed without affecting the carbon nanotube structure." *Id.* at ¶ 60.

8. Liu discloses:

> The chemical functionalizations of carbon nanotubes (CNTs) could enhance their chemical compatibility and dissolution properties, which enable both a more extensive characterization and subsequent chemical reactivity. The modifications with polymers could not only improve CNTs' solubility and dispersibility but also the interfacial interaction to polymeric matrices in its composites. The main methods for the modification of CNTs with polymers are noncovalent attachment (polymer wrapping and absorption) and covalent attachment ("grafting to" and "grafting from").

Liu Abstract.

9. Liu discloses "[i]n many applications it is necessary to tailor the chemical nature of the nanotube's walls in order to take advantage of their unique properties." *Id.* at 2693.

10. Liu discloses:

> Carbon nanotubes functionalized with biological molecules (such as protein peptides and nucleic acids) show great potential for application in bioengineering and nanotechnology. DNA molecules may be encapsulated inside or wrap around CNT owing to van der Waals attraction between DNA and CNT.

Id. at 2694.

11. Liu discloses:

> Tang and Xu reported the soluble multi-walled carbon

> nanotubes (MWNTs)-containing soluble photoconductive poly(phenylacetylenes) (NT/PPAs) are prepared by in situ polymerizations of phenylacetylene catalyzed by WCl_6-Ph_4Sn and $[Rh(nbd)Cl]_2$ (nbd = 2,5-norbornadiene) in the presence of the nanotubes. They demonstrate that the nanotubes in the NT/PPA solutions can be easily aligned by mechanical shear and that the NT/PPA solutions effectively limit intense 532-nm laser pulses.

Id.

ANALYSIS

With respect to claims 1, 2, and 4–7 the Examiner found that Polizu taught "methods of making carbon nanotube-based fibers comprising mixed single wall carbon nanotubes, a biodegradable polymer (PLGA), and a coagulating polymer (PVA) in aqueous solution." Final Act. 3. While PLGA is a biodegradable polymer, the Examiner found that the PLGA disclosed in Polizu was present in aqueous solution, not as a nanoparticle. Ans. 4. Accordingly, the Examiner concluded that Polizu did not disclose a "carbon nanotube-based fiber comprising a nanoparticle of a biodegradable polymer." Final Act. 3.

The Examiner found that Ameer taught that "the use of biodegradable polymers to fabricate nanostructures such as nanofibers." *Id.* In Ameer, "PLGA nanoparticles" are added "dropwise to PVA." *Id.* The Examiner found that Ameer taught that "nanoparticles of a biodegradable polymer such as PGLA act as additional crosslink points during the fabrication of nanocomposites and increase the strength and stiffness (Young's modulus) while decreasing the elongation at break of the nanocomposites." *Id.* at 4.

Based on the combined teachings of Polizu and Ameer, the Examiner concluded that "A skilled artisan would have had a reasonable expectation

. . . that adding a solution of PLGA nanoparticles to a solution comprising a coagulating polymer (PVA) and nanostructures would lead to the production of nanocomposites such as nanofibers with enhanced mechanical properties." *Id.*

While Polizu and Ameer do not expressly recite a "binary colloidal mixture" as recited in claim 1, the Examiner found that this property would be inherent in their combined composition. As evidence of inherency, the Examiner relied upon Smalley's teaching that "when single-wall carbon nanotubes are dispersed in an aqueous system containing a polymer capable of isolating, wrapping, or encapsulating the nanotubes from each other, the nanotubes can be dispersed within the polymer as individual carbon nanotubes and protected from reaggregation." *Id.* at 5. The Examiner explained:

> Based on the teachings of Smalley et al., a skilled artisan at the time of the invention would have appreciated that a hybrid material system obtained by blending a single wall carbon nanotube dispersion, PLGA and PVA in aqueous solution, as taught in Polizu et al., would inevitably result in a binary colloidal mixture in which carbon nanotubes are dispersed within a suspension of PLGA nanoparticles (as taught by Ameer et al.), forming a binary colloidal mixture within a PVA matrix."

Id. at 5.

Appellants disagree with the Examiner's finding that the combined composition of Polizu and Ameer would result in a binary colloidal mixture. Appellants argue that because PGLA nanoparticles act as crosslink points, "adding a solution of PLGA nanoparticles to a solution comprising a coagulation polymer (PVA) and nanostructures, such [as] carbon nanotubes dispersed in water with sodium dodecyl sulfate, as suggested by the

Examiner would result in flocculation of the PVA coated PLGA nanoparticles from the solution." App. Br. 6–7. We are not persuaded.

Smalley teaches that carbon nanotubes can be protected from reaggregation when they are placed in "an aqueous system containing a molecule, compound, or polymer capable of wrapping, encapsulating or otherwise isolating the nanotubes from each other." FF6. Among the molecules that Smalley teaches are capable of "wrapping, encapsulating or otherwise isolating" nanotubes is PVA. FF7. Both the Polizu and Ameer use PVA as a coagulating polymer in conjunction with their nanostructures. *See* FF1 and FF5. Accordingly, it is reasonable to assume that the PVA in the combined composition of Polizu and Ameer would behave as taught in Smalley to wrap, encapsulate or otherwise isolate the nanotubes from each other, thus producing a "binary colloidal mixture."

Appellants argue that "[t]here is no evidence proffered by the Examiner to support the formation of a binary colloidal mixture of carbon nanotubes and PLGA particles in the resulting fiber, much less evidence that would support the high 'necessarily present' standard to support the Examiner's inherency theory." Reply Br. 9. We disagree. As discussed above, Smalley provides substantial evidence to support the Examiner's position that the combination of Polizu and Ameer would inherently produce a binary colloidal mixture. To the extent Appellants contend that the combination of Polizu and Ameer would not produce a binary colloidal mixture, it was incumbent upon Appellants to provide persuasive evidence to demonstrate the absence of inherency. *See In re Best,* 562 F.2d 1252, 1255 (CCPA 1977).

Polizu's nanofibers are prepared using sodium dodecyl sulfate ("SDS"), which appellants identify as a "well known surfactant/detergent that is capable of lysing cells." App. Br. 10. Appellants contend that "the presence of SDS on the surface of Polizu's fibers would render said surface incapable of stimulating and sustaining cell proliferation. Rather, it would likely have the opposite effect by lysing cells." We disagree.

Polizu expressly states "[i]n our new approach, PLGA copolymers, with two different molecular weights, were added in order to obtain a new biocompatible biomaterial." Polizu 6751. Polizu further states: "the surface properties of this material are investigated in order to guarantee a biocompatible response." *Id.* Abstract. We find it unlikely that a material described as "biocompatible" would lyse cells. Accordingly, we find that a preponderance of the evidence supports the Examiner's finding that "a biocompatible biomaterial such as one taught by Polizu would be <u>capable</u> of stimulating and sustaining cell proliferation . . ." Ans. 8.

We affirm the Examiner's rejection of claim 1 as obvious over the combination of Polizu, Ameer, and Smalley. Appellants argue that claims 2 and 4–7 are patentable for the same reasons that claim 1 is patentable. App. Br. 12. Accordingly, we affirm the Examiner's rejection of claims 2 and 4–7 for the reasons discussed above with respect to claim 1.

With respect to claims 3 and 8 Appellants argue that claims 3 and 8 are independently patentable. Both claims 3 and claim 8 depend from claim 1. Claim 3 adds the limitation "wherein said carbon nanotube comprises a multi-wall carbon nanotube." Claim 8 adds the limitation "further comprising additives selected from the group consisting of antibodies, chemical entities, collagen, drugs, growth factors, laminine,

oligonucleotides, peptides, peptide derivatives, siRNA, and mixtures thereof." Appellants argue that "It would not have been obvious to include multi-walled carbon nanotubes or include different additive[s] such as oligonucleotide and peptide, as taught by Liu, in the biocompatible nanotube-based fibers of Polizu et al. to achieve fibers [capable] of stimulating and sustaining cell proliferation." App. Br. at 14. Appellants argue that the methods taught by Liu contradict those taught by Polizu because Polizu's method does not involve nanotubes modified by covalent functionalization or nanotubes dispersed with biomolecules. *Id.* We are not persuaded.

Liu teaches that properties of carbon nanotubes such as solubility, dispersability and compatibility can be improved by modifying the nanotubes with polymers. FF8. Liu also teaches multi-walled carbon-nanotubes, FF11, and states that "[i]n many applications it is necessary to tailor the chemical nature of the nanotube's walls in order to take advantage of their unique properties." FF9. Finally Liu teaches that "[c]arbon nanotubes functionalized with biological molecules (such as protein peptides and nucleic acids) show great potential for application in bioengineering and nanotechnology." FF10. Appellants have not provided persuasive evidence that these teaching contradict or are otherwise incompatible with Polizu's methods. Accordingly, we affirm the Examiner's rejection of claims 3 and 8 as obvious over the combination of Polizu, Ameer, and Smalley.

SUMMARY

For these reasons and those set forth in the Examiner's Answer, the Examiner's final decision to reject claims 1–8 is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a) (1).

AFFIRMED