United States Court of Appeals for the Federal Circuit

E.I. DUPONT DE NEMOURS & COMPANY, ARCHER DANIELS MIDLAND COMPANY,
Appellants

v.

SYNVINA C.V.,
Appellee

2017-1977

Appeal from the United States Patent and Trademark Office, Patent Trial and Appeal Board in No. IPR2015-01838.

Decided: September 17, 2018

MICHAEL J. FLIBBERT, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington, DC, argued for appellants. Also represented by CHARLES COLLINS-CHASE.

PAUL M. RICHTER, JR., Pepper Hamilton LLP, New York, NY, argued for appellee. Also represented by MARK ALEXANDER CHAPMAN, Hunton Andrews Kurth LLP, New York, NY.

Before LOURIE, O'MALLEY, and CHEN, *Circuit Judges*.

LOURIE, *Circuit Judge*.

E. I. du Pont de Nemours and Company and Archer-Daniels-Midland Company (collectively, "DuPont") appeal from an *inter partes* review ("IPR") decision of the United States Patent and Trademark Office Patent Trial and Appeal Board (the "Board"). *See DuPont v. Furanix Techs. B.V.*, No. IPR2015-01838, Paper No. 43, slip op. (P.T.A.B. Mar. 3, 2017) ("*Decision*"). The Board held that DuPont failed to prove by preponderant evidence that claims 1–5 and 7–9 of U.S. Patent 8,865,921 ("'921 patent") would have been obvious at the time of the claimed invention. We conclude that the Board applied the wrong legal standards for obviousness, and reverse.

I. BACKGROUND

Synvina C.V. ("Synvina")[1] owns the '921 patent, directed to a method of oxidizing 5-hydroxymethylfurfural ("HMF") or an HMF derivative, such as 5-methylfurfural ("5MF") or 2,5-dimethylfuran ("DMF"), under specified reaction conditions to form 2,5-furan dicarboxylic acid ("FDCA"). '921 patent Abstract; *id.* col. 7 l. 65. Undisputedly, the oxidation of HMF and its derivatives to yield FDCA was known at the time of the claimed invention. The main issue on appeal is whether the reaction conditions claimed in the '921 patent—specifically, the choice of temperature, pressure, catalyst, and solvent—would have been obvious to a person of ordinary skill at the time of the invention.

A.

DuPont and Synvina are competitors in the production of FDCA for industrial use. FDCA has attracted

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[1] Synvina acquired the '921 patent from Furanix Technologies B.V. ("Furanix"), the patent owner during the IPR proceeding.

commercial interest because of its potential in the "green" chemical industry. Since FDCA can be produced from sugars using biological or chemical conversion, the U.S. Department of Energy has identified FDCA as a potential "building block[]" for "high-value bio-based chemicals or materials." U.S. Department of Energy, Top Value Added Chemicals from Biomass 1 (2004); *see* '921 patent col. 1 ll. 34–36.

The '921 patent claims a method of producing FDCA by oxidizing HMF or an HMF derivative with an oxygen-containing gas such as air. Claim 1 is illustrative and reads as follows:

> 1. A method for the preparation of 2,5-furan dicarboxylic acid comprising the step of contacting a feed comprising a compound selected from the group consisting of 5-hydroxymethylfurfural ("HMF"), an ester of 5-hydroxymethylfurfural, 5-methylfurfural, 5-(chloromethyl)furfural, 5-methylfuroic acid, 5-(chloromethyl)furoic acid, 2,5-dimethylfuran and a mixture of two or more of these compounds with an oxygen-containing gas, *in the presence of an oxidation catalyst comprising both Co and Mn, and further a source of bromine, at a temperature between 140° C. and 200° C. at an oxygen partial pressure of 1 to 10 bar, wherein a solvent or solvent mixture comprising acetic acid or acetic acid and water mixtures is present.*

'921 patent col. 7 l. 61–col. 8 l. 6 (emphasis added). Thus, claim 1 recites four relevant reaction conditions: (1) a temperature between 140°C and 200°C; (2) an oxygen partial pressure ("PO_2")[2] of 1 to 10 bar; (3) a solvent

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[2] PO_2 is the pressure in a gas mixture attributable to oxygen. Adding up the partial pressures of each gas in

comprising acetic acid; and (4) a catalyst comprising cobalt ("Co"), manganese ("Mn"), and bromine ("Br"). *Id.*

The specification describes the reaction conditions in further detail. We begin with temperature. At several points, the specification refers to the reaction occurring at temperatures "higher than 140° C." *Id.* Abstract, col. 2 ll. 41–42, col. 2 ll. 57–58, col. 5 ll. 18–19, col. 5 l. 39, col. 5 l. 57. When the specification refers to the temperature range in claim 1, it states that "[t]he temperature of the reaction mixture is at least 140° C., preferably from 140 and 200° C., most preferably between 160 and 190° C." *Id.* col. 4 ll. 56–58. But "[t]emperatures higher than 180°C. may lead to decarboxylation and to other degradation products." *Id.* col. 4 ll. 58–59.

Second, the specification provides the following guidance regarding reaction pressure:

> The pressure in a commercial oxidation process may vary within wide ranges. When a diluent is present, and in particular with acetic acid as diluent, the temperature and the pressure in such a process are not independent. The pressure is determined by the solvent (e.g., acetic acid) pressure at a certain temperature. The pressure of the reaction mixture is preferably selected such that the solvent is mainly in the liquid phase.

Id. col. 4 ll. 34–41. Because oxygen functions as the oxidant in the reaction, its partial pressure is particularly relevant. "In the case of continuously feeding and removing the oxidant gas to and from the reactor, *the oxygen partial pressure will suitably be between 1 and 30 bar or more preferably between 1 and 10 bar*." *Id.* col. 4 ll. 51–55 (emphasis added).

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the mixture gives the total air pressure. Air consists of about 21% oxygen. *See, e.g.*, *Decision*, slip op. at 17–18.

Third, as indicated above, "[t]he most preferred solvent is acetic acid." *Id.* col. 4 ll. 17–18. Fourth, the catalyst is preferably "based on both cobalt and manganese and suitably containing a source of bromine." *Id.* col. 3 ll. 38–40. The catalyst may also contain "one or more additional metals, in particular [zirconium] and/or [cerium]." *Id.* col. 3 ll. 57–58.

Several dependent claims recite narrower conditions than those recited in claim 1. Claims 2–5 each depend from claim 1. Claim 2 limits the starting material to HMF, esters of HMF, and a mixture thereof. *Id.* col. 8 ll. 7–10. Claims 3 and 4 recite a catalyst with an additional metal, such as zirconium ("Zr") or cerium ("Ce"). *Id.* col. 8 ll. 11–12, 60–61. And claim 5 recites a narrower temperature range between 160 and 190°C. *Id.* col. 8 ll. 62–63.

By conducting the oxidation reaction under the disclosed reaction conditions, the specification states that the inventors "surprisingly" achieved high yields of FDCA, *id.* col. 2 ll. 39–45, and both Furanix and Synvina have pointed to these yields as objective evidence of nonobviousness. The '921 patent reports yields for several reactions under the claimed conditions. Table 1 summarizes results for oxidizing HMF, an ester of HMF, 5-acetoxymethylfurfural ("AMF"), or a mixture of the two to produce FDCA. Multiple experiments were conducted at a temperature of 180°C and a pressure of 20 bars air in an acetic acid solvent. *Id.* col. 6 ll. 34–46. The highest yield of 78.08% was obtained with only HMF as a reactant, while the lowest was 46.85% using AMF alone. *Id.* Table 1.

Table 2 shows the FDCA yields reported in table 1 for the AMF oxidation reactions compared to prior art processes conducted at lower temperatures and a pressure of 30 bars air. *Id.* Table 2; *id.* col. 6 ll. 50–62. FDCA yields achieved using prior art processes were "lower than the

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