A review of recent patents & patent publications in biofuel development

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Patent applications, one measure of innovation in a particular field, are dramatically increasing in the areas of first- and later-generation biofuels. In general, when reviewing patents and patent applications, it is instructive to keep a few points in mind. There are two types of published patent applications: those that have issued and those that have published but are still pending and under examination. This article will look at both; therefore, a foundation to understand what each of these groups of publications means is helpful.

Issued patents have a fixed set of claims at the end of the patent that define the invention regardless of what is included in the detailed-description section. Issued patents are in force 20 years from the filing date, and they give the patent owner the right to exclude others from making, using, and/or selling the claimed invention in the country where the patent issued.

Published patent applications are useful to provide notice to the general public as to potential future patents and their scope. Patent applications are published 18 months after the first filing date and can be useful for both the inventors and competitors. So between the filing date or priority date of the application and the publication date, the patent application is not published and, therefore, not readily available to the public for review.

Inventors use pending patent publications to put likely competitors on notice that the inventor may have enforceable patent rights at some point in the future. Competitors use patent publications to scope out the technology landscape. It is important to note, however, that the existence of a patent publication does not necessarily mean a patent will issue from that application or that the final issued set of claims will look anything like the claims in the publication. They should thus primarily be used for notice and information purposes.

In reviewing the current state of the patent art related to biofuels and biofuel technology, it becomes clear that applications are increasing substantially. The patent publications coming out now are based on applications filed at the end of 2007/beginning of 2008, or those filed in early 2009 but claiming priority back to an application filed in late 2007 or early 2008. Given the number of patent applications filed after January 2008, there is no doubt that the number of patent publications going forward will only increase.

Many, if not most, of the applications in this field are focused on two primary subjects: what to use to create a biofuel and how to process a material to produce a biofuel. As with most developments in the energy field, efficiency is key: Is the material an efficient source of biofuel? Is the process used to produce the biofuel efficient? Is the combustion of the biofuel efficient? Improving efficiency is at the heart of each of the technologies discussed below. (Please note that this article is neither advocating nor determining the patentability of any of these technologies. The content of this paper is directed to an objective summary of some of the biofuel-related patent art.)

This article will touch on six different categories of biofuel and biofuel-related patents and publications internationally. Specifically, the following topics are discussed: fatty acid esters as fuels, wastes as fuels, solid biomass, supplementing biofuels, biofuel production optimization, and biofuel cells.

**Fatty acid esters as fuels**

Many of the patents and publications in this section focus on yield, purity and stability. These particular biofuels have been in the news for some time, but inherent to their properties are hurdles that need to be overcome before these fuels are viable for mass use.

Three recent Japanese patent publications disclose solving some of the problems with utilizing fatty acid esters as fuels. JP 09065887 (Inventors: Fukuda et al; Applicant: Bio-Energy Corporation and Kobe University; Date filed: September 12, 2007) discloses methods of producing fatty acid esters from oils and fats in order to increase the yield of the fatty acid esters. The inventors react the fats and/or oils with straight-chain alcohols and various lipases to produce an improved yield of fatty acid esters suitable for use in a biodiesel fuel.

In JP 09067904 (Inventors: Fukushima et al; Applicant: Ryoko Lime Industry Co. Ltd; Date filed: September 13, 2007), the inventors developed a process to react fats and oils, along with methanol and either calcium hydroxide or calcium oxide in order to produce a dual-layer separation whereby the fuel layer is essentially transparent.

JP 09079134 (Inventors: Imada et al; Applicant: Lion Corporation;
Date filed: September 26, 2007) discloses a method of deriving fatty acid esters from palm oil. Their use of palm oil is based on their understanding of palm crop yields as compared with other oil sources such as soybeans or rapeseed. The inventors combine the palm oil derivatives with propylene oxide to lower the coagulation point of the biofuel.

A group of researchers at the University of Oklahoma is developing methods of producing very long chain polyunsaturated fatty acids, or VLC-PUFAs. These materials can be used in any number of applications, from food products and food supplements to pharmaceuticals, to biodiesel fuels. In US 2009/0203787 (Inventors: Anderson et al; Assignee: The Board of Regents of the University of Oklahoma; Date filed: January 28, 2009), these VLC-PUFAs are disclosed that include chains of at least 28 carbons and are derived from genetically modified plants that are generally considered suitable for producing oils. The inventors contend that the VLC-PUFAs are two to three times longer than conventional fatty acids utilized for biofuels and, therefore, are capable of providing more energy per molecule.

EP 08102466 issued Delgado (Assignee: Industrial Management Company; Date filed: December 20, 2002; Date issued: August 5, 2009) disclosed a process to generate biofuels that are stable and useful at low temperatures. The inventive process involves the transesterification of triglycerides with alcohols to ultimately produce acetals, and/or glycerine acetates. These products are then blended in small amounts with methyl or ethyl esters of fatty acids to produce the subject biodiesel.

EP 0825431 issued to Banavali et al (Assignee: Rohm and Haas Company; Date filed: April 15, 2008; Date issued: August 12, 2009) teaches methods for removing “unsaturation” in fatty acid methyl esters (or triglycerides), which leads to stabilized products suitable for biodiesel fuel.

Biological wastes as fuels

A practical technology for developing useful biofuels comes from the conversion and treatment of biological wastes (or municipal solid wastes). This area of development is especially useful as the global population of both livestock and humans increases.

EP 02086686 (Inventor: Pearse O’Kane, Filing Date: October 6, 2006) discloses the production of biofuel gas from raw municipal solid waste by using an organic digester and dryer. The inorganic materials are separated and removed during the process. The solid “biofuel material” is heated in a depleted-oxygen atmosphere to generate the biofuel gas, which is directed into a storage tank or pipeline.

A group of patent applications owned by Holcim Technology Ltd. is directed to use of waste and/or alternative fuels in the production of clinker or cement. EP 02086902 (Inventors: Flacher et al; Date filed: October 17, 2007) and BR Plo614808 (Inventors: Gasser et al; Date filed: August 11, 2006) disclose processes and devices for utilizing waste and/or alternative fuels, in the presence of oxygen, to provide energy for the clinker or cement production process.

Saito et al, in two Japanese patent applications, JP 09106894 and JP 09106895 (Applicant: Sumitomo Osaka Cement Co. Ltd.; Date filed: October 31, 2007), disclose methods of reducing the water content in organic wastes so that they can be used as fuel for cement calcining equipment and as a biomass fuel. These methods indicate that livestock waste and food waste can be dried and/or dehydrated in order to make them more acceptable as fuel sources. In one method, a “dehydration aid of inflammable particles” is added to organic waste in order to dehydrate it. In the second method, the waste is applied to a small mesh material so that the water is leached away from the waste.

Solid biomass

There are a number of mature applications in this area of combustible biomass-based fuel technology and development. Natural composite fire starters and fire logs for home use are examples of solid biomass functioning as a fuel source.

A recent EP Patent Publication, EP 02090641 (Inventor: Milan Kluko; Applicant: Renewable Densified Fuels, LLC; Date filed: February 12, 2009; Priority Date: February 15, 2008), discloses the use of a cellulosic material in combination with a thermoplastic polymeric material to produce a fuel pellet. The cellulosic material is present in amounts greater than 75 wt%, with the thermoplastic material making up the remainder of the composite. These pellets are useful in coal-fired furnaces or industrial boilers.

WO 2009/102272 (Inventor: Lars Eriksson; Applicant: Katal I. Sverige Aktiebolag; Date filed: February 10, 2009) discloses utilization of solid biomass, such as lignin powder, wood powder, or other pulverized vegetable solid biomass material, with a product of vegetable origin, such as glycerol, to produce a biofuel oil that can be used as a replacement for heavy fuel oil.

Supplementing & enhancing biofuels

This area of biofuel development is seeing rapid growth as biofuels are used in different environments and different types of engines; biofuels that may be stable and usable in the southwestern United States, for example, may be completely nonfunctional in the northeast states, such as Maine, Vermont, and New York (given, e.g., regional average-temperature differences). And biofuels that may be fully functional in an automobile may be completely useless to fuel a boat or plane.

EP 02087074 (Inventors: Li et al; Assignee: Ciba Holding Inc.; Date filed: November 19, 2007) discloses the oxidative stabilizing of biofuels produced from rapeseed or soy oils through addition of sterically hindered phenolic antioxidants and/or triazole metal deactivators. This European application has a corresponding United States Publication, US 2008/0127550.

JP 09524733, filed in January 2007, describes the addition of ignition accelerators, such as peroxides, to biofuels. As part of the disclosure, the application indicates that the ignition accelerators may also improve the lubrication ability, or lubricity, of the fuel.

AU 200824752 (Inventor: Dolivar Coraucci Neto; Applicant: Ouro Fino PARTICIPAÇÕES E EMPREENDIMENTOS SA; Date filed: May 2, 2008) discloses a biodiesel composition formed from microbial oilseed, algal biomass, and/or sugarcane residues and derivatives, wherein algal
biodiesel, and/or glycerol is incorporated into the process, along with extraction and transesterification steps, to produce a biofuel that leaves behind no residues after combustion.

Beyond development of biofuels solely for machinery and automobiles, US 2009/0283420 (Inventor: Arnold J. Cobb; Date filed: January 23, 2008) discloses production of fuels for use in cold- and hot-weather climates, and as jet fuels. Fatty acid methyl esters are crystallized in order to separate the high-melting-point-temperature components from the low-melting-point-temperature components. The low-melting-temperature components are then either used alone or blended with petroleum-diesel jet fuel to form temperature-stable fuels.

Another jet fuel application is disclosed in AU 2007/03541 (Inventors: Ryder et al; Applicant: Amyris Biotechnologies, Inc.; Date filed: November 20, 2007) where bicyclic isoprenoids, such as carane, pinane, sabi-nane, or a combination thereof are used to form the claimed jet fuels. Methods of producing these jet fuels are also disclosed.

EP 02089449 (Inventors: Kormann et al; Applicant: BASF SE; Date filed: October 23, 2007) discloses use of oligo- or polyamines having a number average molecular weight of 46,000 to 70,000 amu in order to increase the oxidative stability of biofuels oils that are free of fatty acid esters.

Optimizing biofuel production

This category regularly makes up the largest class of patents, patent publications, and journal articles, primarily because it is often easier to optimize the production of existing and known biofuels than to develop and test potential new biofuels.

Gary Wietgrefe, in US PATENT PUBLICATION No. 2009/100042 (Assignee: Syngenta Participations AG; Date filed: February 3, 2009), discloses harvesting of plant materials and treating them to form biofuels near the point of harvest, in order to preserve a high moisture content. High moisture content leads to an optimized saccharification and fermentation process that produces a liquefied biomass.

US PATENT PUBLICATION No. 2009/099783 (Inventor: Stacy Miles; Assignee: Syngenta Participations AG; Date filed: January 26, 2009) discloses compositions and methods that increase the expression or accumulation of celllobiohydrodase enzyme in the vacuoles of plant cells. These plant materials can then be utilized to produce various products, including biofuels.

US PATENT PUBLICATION No. 2009/0205363 (Inventor: Ronald de Strulle; Date filed: March 25, 2009) discloses utilization of condensed-phase cryogenic fluids to recover biomass from marine/aquatic and terrestrial environments. The inventor states that this process is “environmentally neutral.”

In another process disclosed as “environmentally benign,” WO 2009/087680 (Inventor: Rangaswamy Vidyaya; Applicant: Reliance Life Sciences Pvt. Ltd; Date filed: December 24, 2008) teaches that Clostridium acetobutylicum (ATCC 10132) can be used to produce high yields of biobutanol without employing “hazardous routes of biofuel production.” The time span of this reaction may also be shortened by using batch processing or adjusting other process parameters.

Mayfield et al, in WORLD PUBLICATION No. 2008/150463 (Assignees: Scripps Research Institute and Sapphire Energy; Date filed: May 30, 2008), teach a method and related compositions to produce biomass-degrading proteins and enzymes in plants and algae that facilitate production of biofuels.

US PATENT PUBLICATION No. 2009/0203116 (Inventor: Keith E. Bazaire; Date filed: February 13, 2009) teaches a process of delivering light and liquid nutrients internally to a photobioreactor in order to improve yield of algae for biodiesel production without increasing energy consumption of the bioreactor and/or process.

WO 2009/094631 (Inventor: Lo et al; Applicants: NewAgriculture, Inc. and the University of Maryland; Date filed: January 26, 2009) describes a new composition, leaf biomass hydrolysate, or LBH, useful as a substrate to promote the “fermentation-based production of biobased industrial chemicals or biofuels.” The claims are directed to production of tobacco leaf biomass hydrolysate. The leaf biomass hydrolysate is also claimed on its own.

WO 2009/091866 (Inventor: Robert D. Wysong; Applicant: Greenlight Biofuels Holdings, LLC; Date filed: January 15, 2009) discloses utilization of homogenous or heterogenous catalysts to continuously remove water during the esterification reaction used to produce biofuels. The end product of the process is “dried” methanol.

US PATENT 7579492 issued to Jerry E. Tysinger (Assignee: Carolina Soy Products LLC; Date filed: September 30, 2003) teaches a two-stage extraction process for maximizing production of soybean oil from soybeans. The extracted oil may then be processed to form a stable biofuel.

Biofuel cells

US PATENT 7572566, issued to Dimitre Karamanov (Assignee: The University of Western Ontario; Date filed: June 25, 2004), claims a new biofuel cell designed around microbial regeneration of ferric ions. Ferric ions are reduced at the cathode to form ferrous ions, which are then regenerated back to ferric ions through the use of chemolithotrophic microorganisms, such as Acidithiobacillus ferrooxidans.

EP 01376729 (Inventors: Aame et al; Applicant: Enfucell Oy; Date filed: June 13, 2003) discloses a biocatalytic direct alcohol fuel cell in which the anode chamber contains a biocatalyst to oxidize the fuel, and the cathode chamber comprises a chemical catalyst, biocatalyst, or combination thereof.

WO 2009/079148 (Inventors: Kim et al; Date filed: November 19, 2008) discloses utilization of carbon nanotube electrodes in biofuel cell and fuel cell applications.

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