US009120712B2

(12) **United States Patent**
Wheeler et al.

(10) **Patent No.: US 9,120,712 B2**
(45) **Date of Patent: *Sep. 1, 2015**

(54) **PROCESS FOR IMPROVING THE ENERGY DENSITY OF FEEDSTOCKS USING FORMATE SALTS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 853 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/331,210**

(22) Filed: **Dec. 20, 2011**

(65) **Prior Publication Data**

US 2012/0203043 A1 Aug. 9, 2012

Related U.S. Application Data

(60) Provisional application No. 61/438,419, filed on Feb. 1, 2011, provisional application No. 61/510,671, filed on Jul. 22, 2011.

(51) **Int. Cl.**

C07C 1/00	(2006.01)
C07C 1/207	(2006.01)
C10G 3/00	(2006.01)

(52) **U.S. Cl.**

CPC ***C07C 1/2078*** (2013.01); ***C10G 3/40*** (2013.01); ***C10G 3/44*** (2013.01); *C10G 2300/1014* (2013.01)

(58) **Field of Classification Search**

CPC C10G 3/00; C10G 2300/101; C10G 2300/1011; C10G 17/10; C07C 7/00; C07C 7/04

USPC 585/240, 242; 560/155, 165

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,969,189 A 10/1999 Holtzapple et al.
6,043,392 A 3/2000 Holtzapple et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1643116 A 7/2005
EP 2 025 735 A1 2/2009

(Continued)

OTHER PUBLICATIONS

Barth et al., "Motor Fuels From Biomass Pyrolysis", Chem. Eng. Technol., 31(5):773-781 (2008).

(Continued)

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(57) **ABSTRACT**

Methods of forming liquid hydrocarbons through thermal deoxygenation of cellulosic compounds are disclosed. Aspects cover methods including the steps of mixing a levulinic acid salt-containing feedstock with a formic acid salt, exposing the mixture to a high temperature condition to form hydrocarbon vapor, and condensing the hydrocarbon vapor to form liquid hydrocarbons, where both the formic acid salt and the levulinic acid salt-containing feedstock decompose at the high temperature condition and wherein one or more of the mixing, exposing, and condensing steps is carried out a pressure between about vacuum and about 10 bar.

16 Claims, 5 Drawing Sheets