

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization

International Bureau

(43) International Publication Date
25 November 2021 (25.11.2021)



(10) International Publication Number
WO 2021/236746 A1

(51) International Patent Classification:

H01M 8/18 (2006.01) **H01M 8/0273** (2016.01)

H01M 8/20 (2006.01)

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

(21) International Application Number:

PCT/US2021/033119

Published:

— with international search report (Art. 21(3))

(22) International Filing Date:

19 May 2021 (19.05.2021)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

16/878,165 19 May 2020 (19.05.2020) US

(71) Applicant: **RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY** [US/US]; 83 Somerset Street, New Brunswick, NJ 08901 (US).

(72) Inventors: **DISMUKES, Charles, G.**; 241 Washington Road, Princeton, NJ 08540 (US). **LAURSEN, Anders**; 11 Maiden Lane, Apt. 4D, New York, NY 10038 (US). **CALVINHO, Karin**; 1 Richmond Street, Apt. 3001, New Brunswick, NJ 08901 (US).

(74) Agent: **BUTCH III, Peter, J.** et al.; Fox Rothschild LLP, 997 Lenox Drive, Lawrenceville, NJ 08648-2311 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: LEWIS/BRONSTED ACID/BASE AND NICKEL PHOSPHIDE BINARY CATALYST-SYSTEM (CO-CATALYSTS) FOR DIRECT ELECTROCHEMICAL CO₂ REDUCTION TO HYDROCARBONS

(57) Abstract: Disclosed are cathodes comprising a conductive support substrate having an electrocatalyst coating containing nickel phosphide nanoparticles and a co-catalyst. The conductive support substrate is capable of incorporating a material to be reduced, such as CO₂ or CO. A cocatalyst, either incorporated into the electrolyte solution, or into the conductive support, or adsorbed to, deposited on, or incorporated into the bulk cathode material, alters the electrocatalyst properties by increasing the carbon product selectivity through interactions with the reaction intermediates. Also disclosed are electrochemical methods for selectively generating hydrocarbon and/or carbohydrate products from CO₂ or CO using water as a source of hydrogen.



WO 2021/236746 A1