

Supplementary Materials

Production of 5-Hydroxymethylfurfural from Direct Conversion of Cellulose Using Heteropolyacid/ Nb_2O_5 as Catalyst

Jéssica Siqueira Mancilha Nogueira ¹, Vinícius Tomaz Santana ¹, Paulo Vitor Henrique ¹, Leandro Gonçalves de Aguiar ¹, João Paulo Alves Silva ¹ and Solange I. Mussatto ^{2,*} and Livia Melo Carneiro ¹

¹ Department of Chemical Engineering, Engineering School of Lorena, University of São Paulo, 12602-810 Lorena, São Paulo, Brazil; jessicasmn@usp.br (J.S.M.N.); viniciustsantana@usp.br (V.T.S.); paulos.vh@usp.br (P.V.H.); leandroaguiar@usp.br (L.G.d.A.); jpalves80@usp.br (J.P.A.S.); liviacarneiro@usp.br (L.M.C.)

² Novo Nordisk Foundation Center for Biosustainability, Technical University of Denmark, 2800 Kongens Lyngby, Denmark

* Correspondence: smussatto@dtu.dk or solangemussatto@hotmail.com; Tel.: +45 93 51 18 91

1. Bibliometric Analysis

The bibliometric analysis evaluated the occurrence of the term ‘Hydroxymethylfurfural’ in Abstracts of published studies. From this analysis, it was noted that, during the last decade, there has been a constant growth in the number of indexed scientific documents, from around two hundred documents in 2011 to almost six hundred documents in 2019 (Figure S1).

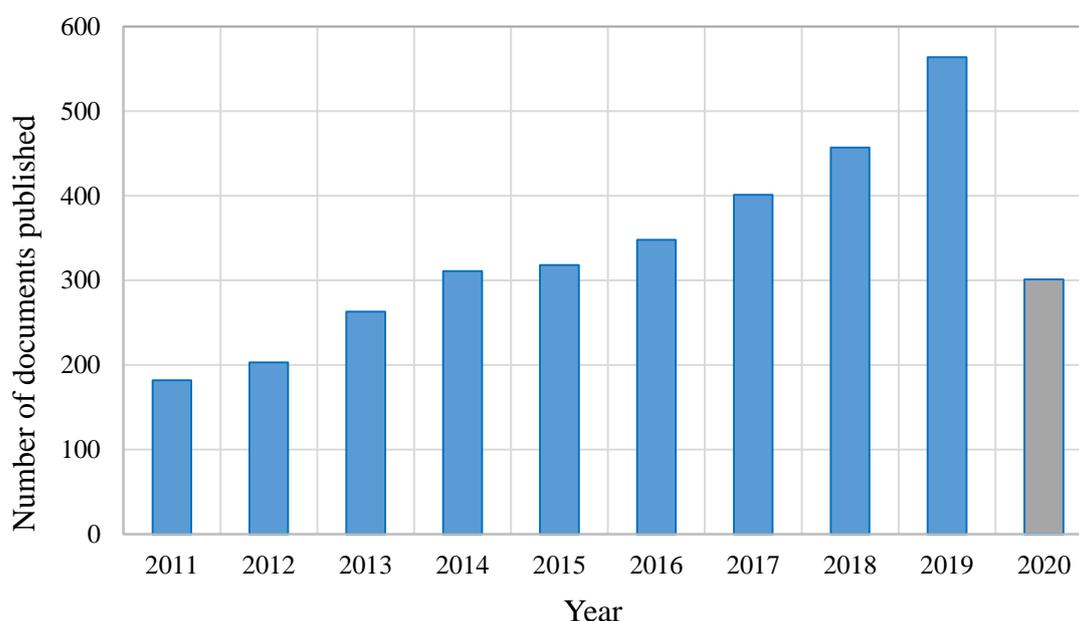


Figure S1. Number of papers published per year referring to the occurrence of the term ‘Hydroxymethylfurfural’ in studies published from 2011 to 2020. Bibliometric analysis carried out on the Scopus search platform on June 23, 2020.

The occurrence of the key terms combinations (Hydroxymethylfurfural; Cellulose; solid catalyst; heterogeneous catalyst) in Abstracts of published papers was also evaluated in the bibliometric analysis, in order to refine search for relevant studies in the area (Table S1). In this analysis, it was noted that the use of heterogeneous catalysts for converting cellulose into hydroxymethylfurfural in

the last ten years is still little explored, only twenty-four occurrences were found on the Scopus platform for such terms combination. The increasing number of works on HMF and the still small number of studies that report the use of heterogeneous catalysts for converting cellulose into HMF show the novelty of the present work.

Table S1. Search criteria and number of documents found in the bibliometric analysis of the Scopus search platform on June 23, 2020.

Search criteria	Number of documents
Period: 2011 – 2020	
Included in the Abstract the following terms: Hydroxymethylfurfural	3.348
Period: 2011 – 2020	
Included in the Abstract the following terms: Hydroxymethylfurfural Cellulose	428
Period: 2011 – 2020	
Included in the Abstract the following terms: Hydroxymethylfurfural Cellulose catalyst	211
Period: 2011 – 2020	
Included in the Abstract the following terms: Hydroxymethylfurfural Cellulose Solid catalyst	48
Period: 2011 – 2020	
Included in the Abstract the following terms: Hydroxymethylfurfural Cellulose heterogeneous catalyst	24

2. Kinetic study results

Table S2. Cellulose concentration (mol/L) and conversion (%), HMF concentration (mol/L e g/L) and yield (%) obtained in the HMF production from cellulose at 180 and 200 °C with time ranging from 10 to 60 minutes.

Temperature (°C)	Time (min)	C _{Cel} ¹ (mol/L)	X _{Cel} ² (%)	C _{HMF} ³ (mol/L)	C _{HMF} ³ (g/L)	Y _{HMF} ⁴ (%)
180	10	0.428	30.6	0.049	6.2	7.9
	15	0.386	37.4	0.055	6.9	8.9
	30	0.352	43.0	0.069	8.7	11.2
	45	0.330	46.5	0.071	9.0	11.5
	60	0.297	51.8	0.078	9.8	12.7
200	10	0.153	75.2	0.111	14.1	18.1
	15	0.074	88.0	0.116	14.6	18.8
	30	0.024	96.2	0.119	15.0	19.3
	45	0.016	97.3	0.111	14.0	18.0
	60	0.012	98.0	0.096	12.1	15.5

¹C_{Cel}: Cellulose concentration. ²X_{Cel}: Cellulose conversion. ³C_{HMF}: HMF concentration. ⁴Y_{HMF}: HMF yield.