Supporting Information

Sulfonation of natural carbonaceous bentonite as low-cost acidic catalyst for effective transesterification of used sunflower oil into diesel; statistical modeling and kinetic properties

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Content

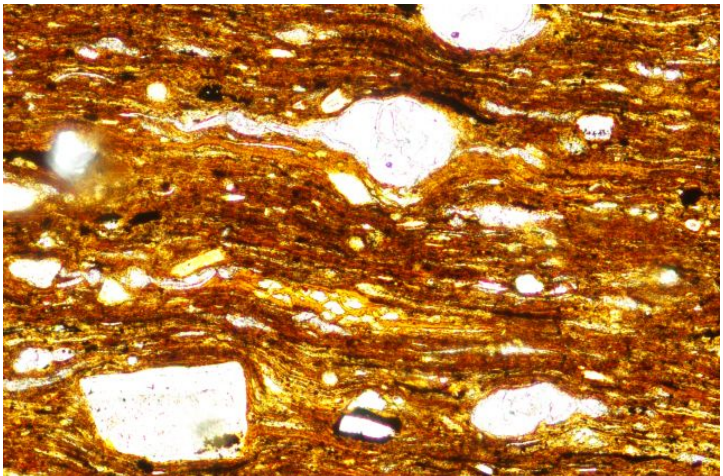

Figure S1. the petrographic studies of oil shale in thin sections using polarized transmitted microscope

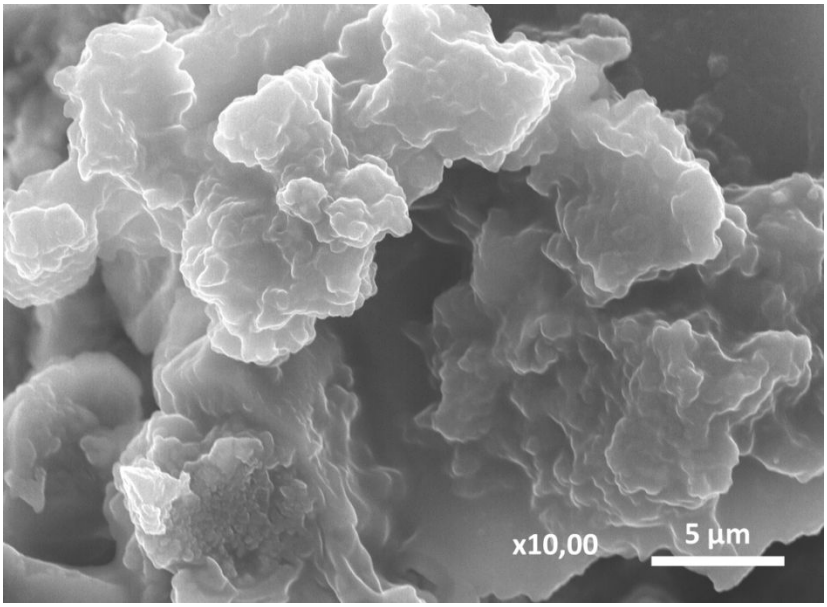

Figure S2. SEM image of the S-CB catalyst after the transesterification reactions (Spent catalyst)

(S2)

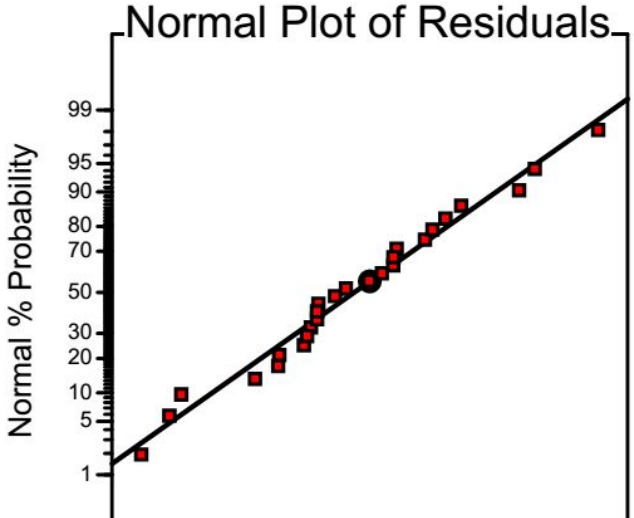

Figure S3. the normal probability plot for studentized residuals for the suggested experimental conditions

Table S1. The optimization test scheme constraints for the suggested optimizing conditions for the transesterification of SFO over S-CB catalyst

Optimization test scheme constraints						
Name		**Lower Limit**	**Upper Limit**	**Lower coded**	**Upper coded**	**Importance**
Time	Is in range	20 min	150 min	1	1	3
Temperature	Is in range	25 ^{o}C	75 ^{o}C	1	1	3
Methanol:oil ratio	Is in range	4:1	15:1	1	1	3
Catalyst loading	Is in range	2 wt.,%	5 wt.,%	1	1	3
Biodiesel yield	Maximum					

Table S2. the determination coefficient and the rate constant for the studied Pseudo-first order kinetic model

Temperature	**Determination coefficient (R^2)**	**Rate constant (k)**
50 ^{o}C	0.98	0.02992
60 ^{o}C	0.98	0.03651
70 ^{o}C	0.95	0.04156

Table S3. the Fatty acid content and physical properties of the inspected spent sunflower oil

(S3)

Fatty acid composition	
Fatty acid composition	**Percent**
Myristic acid ($C_{14}H_{28}O_2$) (C14:0)	**11.3 %**
Linoleic acid($C_{18}H_{32}O_2$) (C18:3)	**15 %**

Palmitoleic ($C_{16}H_{30}O_2$) (C16:1)	**33.8 %**
Oleic acid ($C_{18}H_{34}O_2$) (C18:1)	**30.6 %**
Palmitic acid ($C_{16}H_{32}O_2$) (C16:0)	**2.3 %**
Eicosanoic acid ($C_{24}H_{48}O_2$) (C20:1)	**2.5 %**
Stearic acid ($C_{18}H_{36}O_2$) (C18:0)	**1.8 %**
Physical properties	
Molecular weight	922 g/mol
Saponification value	187 mg KOH/gm
Acid value	2.23 mg KOH/gm
Kinematic viscosity	45.2 cSt

Table S4. the upper and lower values of the inputs in their actual and coded values

Factor	Name	Low actual	Medium actual	High actual	Low coded	Medium coded	High coded
A	**Temperature (°C)**	25	50	75	-1	0	1
B	**Time (min)**	20	85	150	-1	0	1
C	**Methanol/oil ratio**	4/1	9.5/1	15/1	-1	0	1
D	**Loading (wt.,%)**	2	3.5	5	-1	0	1