Acidic waste cooking oil valorization by biodiesel synthesis catalyzed by 1-butyl-3-methylimidazolium hydrogen sulfate

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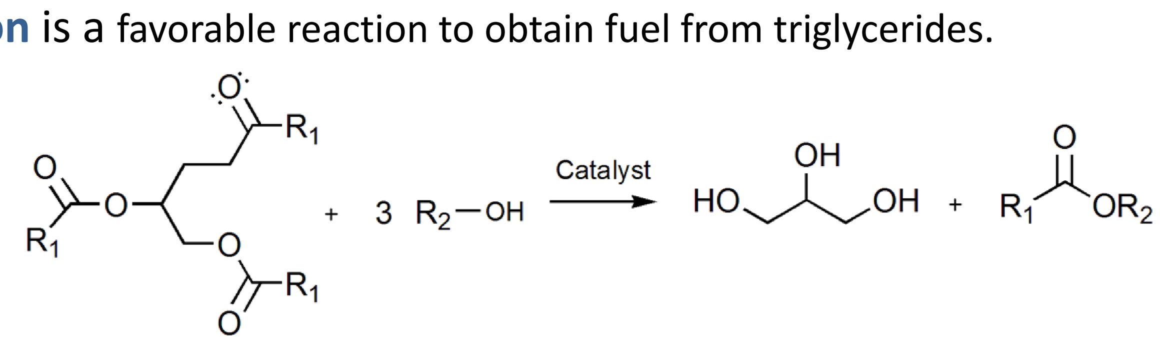
BACKGROUND

Biodiesel

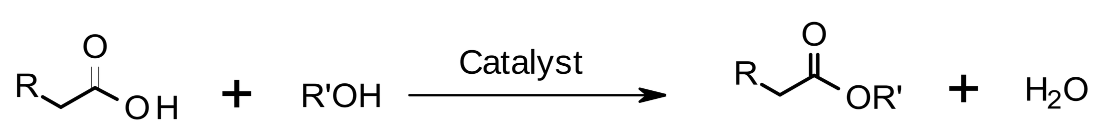
- Also referred to as Fatty Acids Methyl Esters (FAMEs).
- Obtained through renewable raw materials, as animal and vegetable oils and fats.
- Biodiesel can partially or completely replace petroleum diesel.

Production Methods

Transesterification is a favorable reaction to obtain fuel from triglycerides.



Esterification is an option for the conversion of free fatty acids (FFA) present in oils.



Catalysts

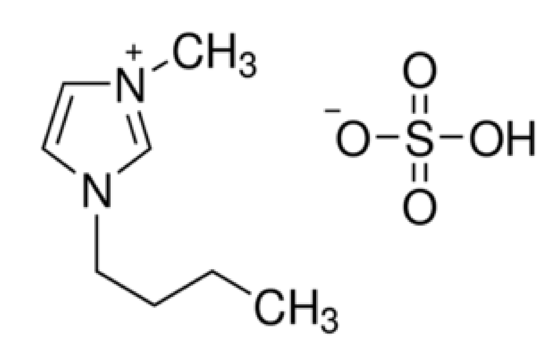
In both reactions, the presence of **catalysts** is required for an effective conversion.

- Alkali catalysts are not capable of catalyzing the esterification reaction and may lead to the saponification reaction.
- Acid catalysts promote both transesterification and esterification reactions but present several drawbacks.

Ionic Liquids (IL)

IL are environmentally-friendly catalysts resulting in high conversions in biodiesel production. They have possibility of designing a specific molecule and ability to recycle and reuse.

1-butyl-3-methylimidazolium hydrogen sulfate [BMIM]HSO₄



LITERATURE REVIEW

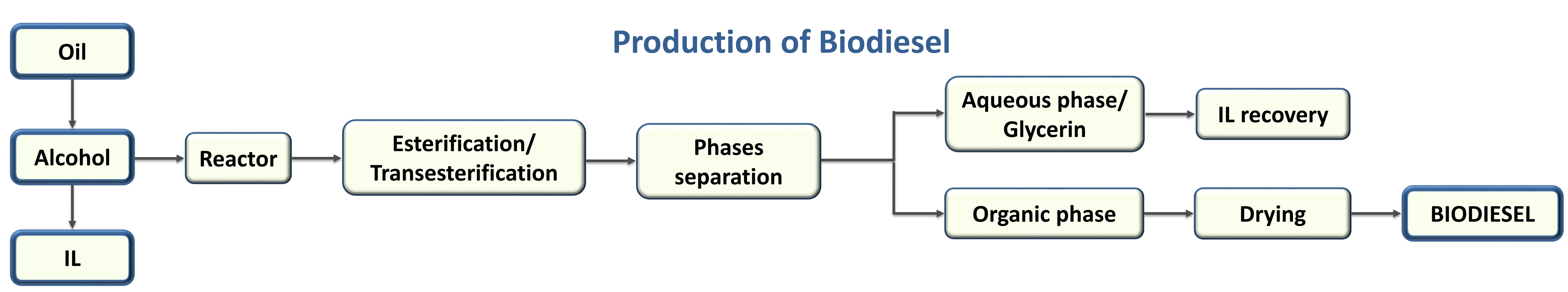
Imidazolium-based IL have been the most studied for biodiesel production, including 1-butyl-3-methylimidazolium hydrogen sulfate [BMIM]HSO_4, which has been showing promising results.

Reaction	Feedstock	Molar Ratio alcohol/oil (mol/mol)	Catalyst Dosage (wt%)	Temperature (°C)	Reaction Time (h)	Conversion (%)	REF.
Transesterification	crude palm oil	12:1	4.4	160	2	91.2	[1]
Esterification	oleic acid	9:1	3.4	90	4	84.4	[2]
Esterification	oleic acid	9:1	1.2	87	5.2	81.8; 80.4[a]	[3]
Transesterification	Camptotheca acuminata seed oil	6:1	5	60	0.5	38.5	[4]
Esterif. / Trans.	palm oil	15:1	5	160	1	95.6[b]	[5]
Esterification	oleic acid	10:1	10	90	4	89.7	[6]
Esterification	oleic acid	10:1	20	90	6	84.8	[7]

[a] 81,8% e 80,4% for the yield of methyl oleate and the conversion of oleic acid; [b] after esterification with IL and transesterification with KOH.

RESULTS

Production of Biodiesel



Feedstock caracterization

Waste Oil (WO)			Oleic Acid (OA)		
Fatty acids (%wt)	Fatty acid composition (%wt)	Acidity (mg KOH/g_{oil})	FAME (%wt)	FAME content (%wt)	Acidity (mg KOH/g_{acid})
79.0	30.9 oleic acid 35.6 linoleic acid	4.8	96.4	87.2 methyl ester of oleic acid	183.4

- **Oils** with **high acidity** simulated by the incorporation of OA in the waste oil with variable proportions.

Experimental planning

- Full Factorial design with 3 factors at 2 levels (2^3), with a replica.
- Study of 2 responses: **Reduction of Acidity** and **Content of FAME** of the biodiesel sample produced.
- **Responses** measured by **acid-base volumetric analysis** and **gas chromatography**, respectively.

Fixed operational parameters: Reaction Temperature: 65°C; Catalyst Dosage: 10%wt.

Sample	Incorporation of OA (%)	Molar Ratio alcohol/oil (mol/mol)	Reaction Time (h)	Conversion (%)	FAME content (%wt)
1	20	1:20	4	94.2	16.6
2	20	1:40	4	96.0	15.6
3	20	1:20	8	97.0	21.2
4	20	1:40	8	97.4	16.6
5	40	1:20	4	88.8	33.9
6	40	1:40	4	94.3	31.1
7	40	1:20	8	94.7	39.0
8	40	1:40	8	95.2	28.6

Only the **Esterification** reaction has occurred. This conclusion is supported by the following reasons: absence of glycerol formation; FAME contents below the incorporation % of oleic acid; FAME consisting essentially of methyl esters of oleic acid.

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