Laboratory 1. Chemicals in Biodiesel Preparation

1.1. Key learning points

1.1.1. Learn different types of organic molecules relevant to biodiesel and its production, including hydrocarbons, fatty acids, alcohols, triglycerides, methyl esters, sodium/potassium hydroxides, sodium/potassium methoxides, and glycerol.
1.1.2. Learn categorization of chemicals, e.g., hydrocarbons, alcohols, esters, etc.
1.1.3. Learn 3-D configuration of some of the some molecules aforementioned by making models, e.g., stearic acid methyl ester, and tri-stearic glyceride.

Laboratory 2. Atomic and Molecular Weights and Their Calculations

2.1. Key learning points

2.1.1. Learn / review the Periodic Table.
2.1.2. Learn concept of atomic weight of elements.
2.1.3. Learn calculating molecular weights using atomic weights of elements.
2.1.4. Learn calculating average molecular weights of multi-component mixtures using molecular weights of chemicals.

Laboratory 3. Acid values / pH of Vegetable Oils via Titration

3.1. Key learning points

3.1.1. Learn concepts of acidity and pH values in aqueous solution.
3.1.2. Learn concepts of water dissociation and pKa ($H^+ + OH^- <==> H_2O$)
3.1.3. Learn concepts of acidity and acid values in organic solution.
3.1.4. Learn concepts of different titration color indicators and their responses to pH ranges.
3.1.5. Learn titration techniques
3.1.6. Learn how to obtain acid values of vegetable oils

Laboratory 4. Chemical Reaction between Hydroxide and Alcohol (Catalyst Solution Preparation for Biodiesel production)

4.1. Key learning points

4.1.1. Learn concept of solubility of a chemical dissolving in another.
4.1.2. Learn concept of solubility and dissolving physically and chemically.
4.1.3. Learn chemical reaction of sodium hydroxide and methanol to form sodium methylate and water ($NaOH + CH_3OH ==> NaOCH_3 + H_2O$).
4.1.4. Learn calculating the concentrations of sodium methylate in methanol solution; conversion between molar and mass concentrations.
4.1.5. Learn the concept of water being an undesired by-product in methylate preparation.

Laboratory 5. Reversible and irreversible Chemical Reactions and Stoichiometry

5.1. Key learning points

5.1.1. Learn concepts of esterification and transesterification.
5.1.2. Learn concept of reversible and irreversible chemical reactions.
5.1.3. Learn concept of stoichiometry.
5.1.4. Learn concept of catalysis.
5.1.5. Learn concept of kinetics involving excessive reactant(s).

Laboratory 6. Transesterification of Vegetable Oil and Alcohol to Produce Methyl Esters or Biodiesel

6.1. Key learning points

6.1.1. Learn that transesterification is a reversible chemical reaction; that excess methanol is needed to completely convert vegetable oil to esters; that a catalyst is required; that additional catalyst is required to neutralize free fatty acid/ compensate acidity.
6.1.2. Learn that the transesterification is a liquid phase reaction and mixing of vegetable oil with methanol is necessary; that methanol has limited solubility in vegetable oil.
6.1.3. Learn that elevated temperature and agitation are needed for the chemical reaction.
6.1.4. Learn that side reactions/saponification occur simultaneously.
6.1.5. Learn by-product glycerol can by separate easily by gravity / density difference.

Laboratory 7. Extraction of Minerals from Organic Solution/ Methyl Ester Washing

7.1. Key learning points

7.1.1. Learn that small quantity of methanol exists in methyl esters despite its low solubility.
7.1.2. Learn that small quantity of minerals exist in the form of sodium methylate.
7.1.3. Learn concept of no minerals in fuels.
7.1.4. Learn that impurities in esters can be cleaned by extraction.
7.1.5. Learn concept of solvent extraction and partition factors of minerals in solvents.
7.1.6. Learn solvent extraction calculation, and single-step vs. multi-step extractions.

Laboratory 8. Density Measurement of Pure and Mixtures of Chemicals and Fuels

8.1. Key learning points

8.1.1. Learn concept of density is a physical property of chemical compounds.
8.1.2. Learn concept of density change vs. temperature.
8.1.3. Learn that organic compounds typically denser than inorganic compounds.
8.1.4. Learn to determine densities of pure chemicals and mixture/blends of methyl esters and diesel fuel, such as methanol, glycerol, vegetable oils, methyl esters, and diesel.