Degumming and Centrifuge Selection, Optimization and Maintenance

IUPAC-AOCS Workshop on Fats, Oils and Oilseeds Analysis and Production

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Purpose of Degumming

- Commercial Lecithin production
- Prevent crude oil settling during storage or transport
- Waste water (prevent acidulation of gums)
- Physical Refining
- Reduction in neutralisation losses
Gums

• Two main types
  – Hydratable Phosphatides - easy to remove
  – Non-Hydratable Phosphatides (NHP) - hard to remove from oil
    • Some NHP removed with hydratables in water degumming
    • requires the use of an acid to convert to hydratable for complete removal
# Gum Content of Various Oils

<table>
<thead>
<tr>
<th>Oil type</th>
<th>Phosphatides (%)</th>
<th>Phosphorus (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut</td>
<td>0.02 – 0.05</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Corn</td>
<td>0.7 – 2.0</td>
<td>250 – 800</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>1.0 – 2.5</td>
<td>400 – 1000</td>
</tr>
<tr>
<td>Groundnut</td>
<td>0.3 – 0.7</td>
<td>100 – 300</td>
</tr>
<tr>
<td>Palm</td>
<td>0.03 – 0.1</td>
<td>15 – 30</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>0.5 – 3.5</td>
<td>200 – 1400</td>
</tr>
<tr>
<td>Soya</td>
<td>1.0 – 3.0</td>
<td>400 – 1200</td>
</tr>
<tr>
<td>Sunflower</td>
<td>0.5 – 1.3</td>
<td>200 – 500</td>
</tr>
</tbody>
</table>
Physical Refining

Feedstock Parameters

• Seed Oil (Soybean, Rapeseed, Sunflower)
  – FFA \leq 2\%
    • higher FFA indicates low quality oil and may not be suitable for physical refining
  – Phosphorous \leq 5 \text{ ppm}, \leq 2 \text{ desired}
  – Iron \leq 0.2 \text{ ppm}
Chemical Refining

Feedstock Parameters

- Seed Oil (Soybean, Rapeseed, Sunflower)
  - FFA ≤ 3%
  - Phosphorous ≤ 1200 ppm, ≤ 200 ppm desired
Water Degumming Process Steps

- Heat oil to 60 - 70 °C
- Water addition and mixing
- Hydration mixing 30 minutes
- Centrifugal separation of hydrated gums
- Vacuum drying of degummed oil
- Gums - dried for edible lecithin or recombined in meal
Water Degumming

- Water
- Crude oil
- Mixer
- Reactor
- Separator
- Gums
- Vacuum dryer
- To storage
- Heater
- Steam
Water Degumming

Target Results:

- Phosphorous in oil - 50 to 200 ppm max.
- Al% in dried gums - 65 to 70%.
- Moisture in dried oil - < 0.1%.
Acid Degumming Process Steps

• Heat oil to 60 - 70 °C
• Acid addition and mixing
• Hydration mixing 30 minutes
• Centrifugal separation of hydrated gums
• Vacuum drying of degummed oil
• Gums - recombined in meal
Acid Degumming

Crude oil → Heater → Steam → Acid → Mixer → Reactor → Separator → Gums → To drying/storage
Acid Degumming

Target Results:

- Phosphorous in oil - 20 to 50 ppm max.
- AI% in dried gums - 65 to 70%
- Moisture in dried oil - < 0.1%
Major Deep Degumming Methods

- Alfa Laval Special Degumming
- Super/Uni Degumming
- TOP Degumming
- Organic Refining Process
- Soft Degumming
- Enzymatic Degumming
Deep Degumming

• Deep degumming utilizes a reagent like acid to chelate Iron, Calcium, and Magnesium away from the NHP complex. Once the Iron, Calcium, and Magnesium are removed from the NHP complex the phosphatide becomes hydratable.

• Enzymatic degumming utilizes an enzyme to modify the NHP into a hydratable form.
Alfa Laval Special Degumming

- Heat oil to 60 °C
- 0.05-0.2 % Phosphoric Acid with intensive mixing
- Partially neutralise with dilute lye (hydration water)
- Gentle mixing and holding for 60 minutes
- Gums centrifugation
- Optional water wash step for lower phosphorous
- Oil drying
Alfa Laval Special Degumming
Alfa Laval 2-stage Special Degumming

Crude oil -> Heater (Steam) -> Mixer -> Acid, Lye -> Neutralising route (Oil temperature trimmer) -> Reactor (Cooling water) -> Steam -> Separator (Gums or soap-stock) -> Mixer (Water) -> To drying/storage (Waste water)
Alfa Laval Special Degumming

Target Results:

- Phosphorous in oil - 20 to 30 ppm max.
- Phosphorous in oil - 8 to 10 ppm max. with washing
- AI% in dried gums - 50 to 60%
- Moisture in dried oil - < 0.1%
## Deep Degumming Results

<table>
<thead>
<tr>
<th>Process</th>
<th>Phosphatides (％)</th>
<th>Phosphorus (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Degumming</td>
<td>≥ 0.02</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Super Uni Degumming</td>
<td>0.01 – 0.04</td>
<td>5 – 15</td>
</tr>
<tr>
<td>TOP Degumming</td>
<td>0.01 – 0.02</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Soft Degumming</td>
<td>&lt; 0.01</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>ORP</td>
<td>&lt; 0.02</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Enzymatic Degumming</td>
<td>0.01 – 0.02</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Ultrafiltration</td>
<td>&lt; 0.01</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>
Disc Stack Centrifuges

Alternative name: High Speed Separators (HSS)
Separation by Density Difference

Stokes’ Law

\[ V_g = \frac{d^2 (\rho_p - \rho_l)}{18 \eta} g \]

- \( V_g \) = gravitational settling velocity (m/s)
- \( d \) = particle diameter (m)
- \( \rho_p \) = particle density (kg/m\(^3\))
- \( \rho_l \) = liquid phase density (kg/m\(^3\))
- \( \eta \) = liquid phase viscosity (kg/ms)
- \( g \) = gravitational acceleration (m/s\(^2\))
Centrifugal Separation
Forces coalescence/sedimentation

Settling velocity stated by Stokes’ Law

Gravity separation.
Driving force: 1g

Centrifugal separation.
Driving force: $r \cdot \omega^2$

Settling velocity = $V$

Settling velocity = $V_c$
Clarification

- Removal of solids phase from a mixture of liquid and solids
Concentration

- Liquid/liquid separation (also solids if present)
- Maximum cleaning of the heavy phase
- Therefore holes in disc-stack closer to the centre
Purification

- Liquid/liquid separation (also solids if present)
- Maximum cleaning of the light phase
- Therefore holes in disc-stack closer to the periphery
HSS – Bowl Development

1890

1948

1993
Optimising Separation Performance

Fluid Handling

Gentle inlets
- Increase capacity
- No emulsion formation

Hermetic inlet

Disc inlet working principle

Lab tests

www.alfalaval.com
Optimising Separation Performance

Fluid Handling

Porcupine outlet
• Reduced cavitation
• Reduced air entrainment
• Reduced break-up of particles
Optimising Separation Performance

Fluid Handling

Adjustable paring disc
• Adjustable during operation
• Flexible
• Reduced energy consumption
HSS Optimization - bowl design

- Optimized bowl and disc stack improve separation and reduce product loss.
- High capacity for handling sticky and viscous gums and soaps.
- Improved design and new high-performance stainless steel give the bowl optimal resistance to metal fatigue.
HSS Optimization - disc stack

The disc-stack

Flow between discs

5000 g

Liquid

Solids

0.5 mm
Disc Stack

- **Caulks**
- **Thickness**
  - 0.4 - 2 mm
- **Number**
  - From 30 on small separators to more than 200 on large
Recommended Maintenance Intervals

- Lubricating oil change every 1500 hours
- Intermediate service every 2000 hours
  - overhaul of bowl and inlet/outlet device
- Major service every 8000 hours
  - overhaul of complete separator
Intermediate Service

- Outlet
  - clean and inspect. Renew o-rings

- Bowl
  - clean and inspect. Check for signs of corrosion or erosion
  - Renew o-rings

- Drive system
  - check worm and worm wheel. Renew lubricating oil

- Monitoring equipment
  - check function of vibration and speed sensors
Major Service

- **Inlet**
  - clean and inspect. Renew o-rings

- **Outlet**
  - as per Intermediate Service

- **Bowl**
  - as per Intermediate Service

- **Drive system**
  - clean and inspect worm, worm wheel and spindle. Renew bearings, rubber buffers, gaskets, o-rings and lubricating oil
Why Planned Maintenance

- Reduced risk of unplanned stops.
- Resource allocation.
- Higher ROI by prolonged service intervals.
- Planned service.
- Pre-ordering of parts.
- Increased service quality by status check after service.
- Increased safety.

Maximize uptime and minimize operating cost!