Texas A&M Short Course

Vegetable Oil Processing and Products of Vegetable Oils

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Nano Neutralization™ – Step Change in Edible Oil Processing through Chemical Economy and Yield Improvement

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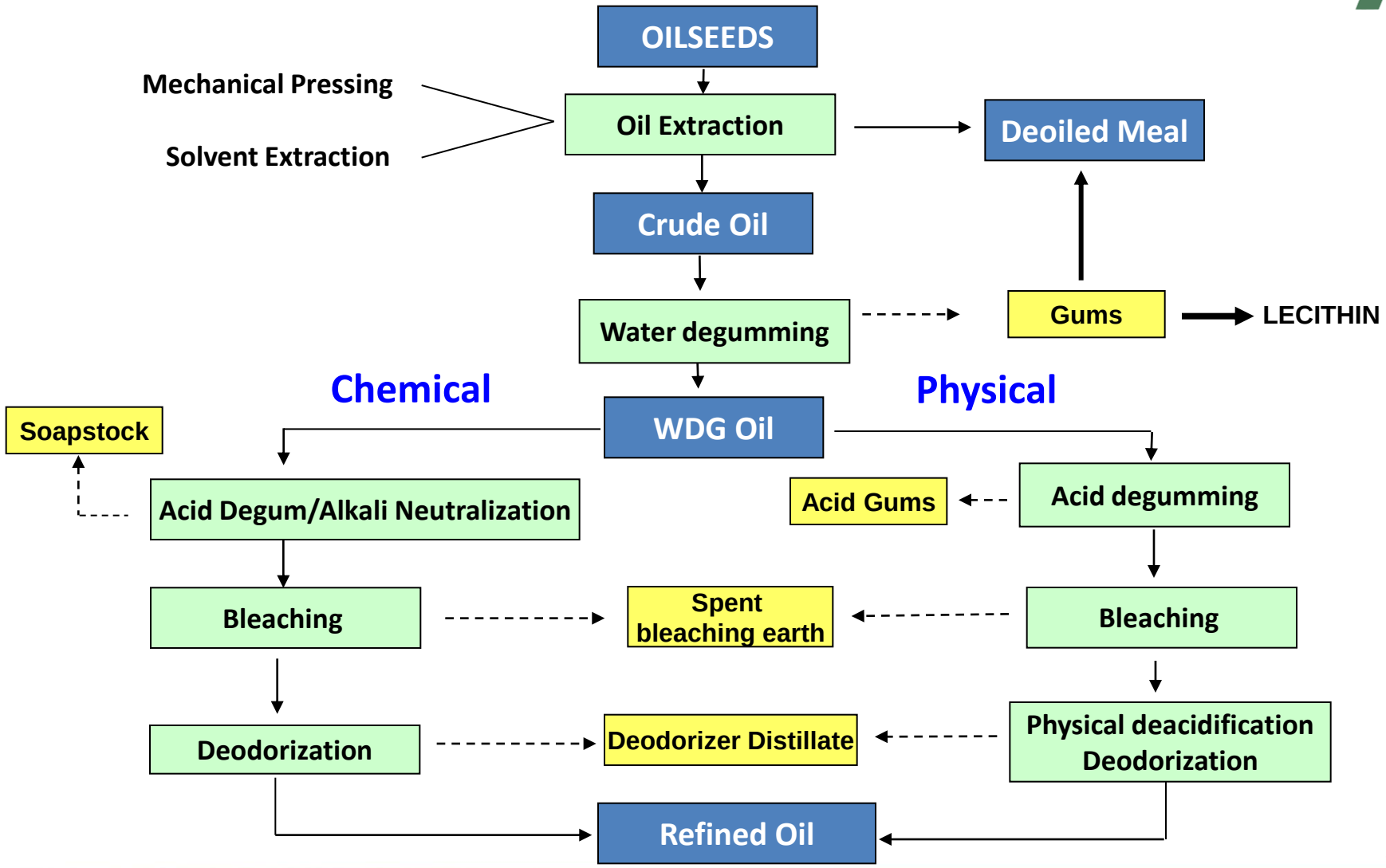
Physical vs Chemical Refining



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Chemical Refining

Still most widely applied refining process

** Independent of crude oil quality ('forgiving' process);*

** Usually gives good refined oil quality ('effect of caustic');*

** Most suitable process for stand-alone refineries;*

But, with its known drawbacks

** High neutral oil losses in the soapstock (especially for higher FFA oils) ;*

** Low value of the soapstock or acid oil;*

** Difficult and expensive wastewater treatment (environmental issue) ;*

→ **Clear demand for improved chemical refining**

Developments in Chemical Refining

Better value-enhancement of soapstock

** Dry chemical refining with CaO (formation of Ca-soaps);*

** Chemical refining with KOH (formation of K-soaps);*

** Not applied on industrial scale (not consistent, too high operating cost,..)*

Mechanical improvements

** Centrifugation : from tubular bowl to continuous selfcleaning machines ;*

** Use of better, more powerful mixing systems (less excess chemicals)*

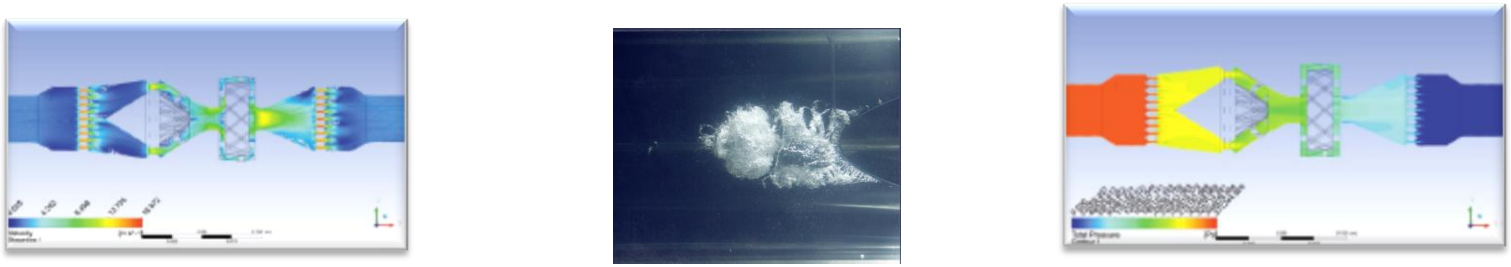
Process improvements

** Replacing water washing by dry 'silica' post-treatment (less waste water);*

** **Nano-reactor technology (only recently industrially applied)***

Nano Reactors®

- *Hydrodynamic cavitation principle*
- Effects are generated by pumping two liquids (e.g. oil + water) – from which at least one is low boiling - at high pressure through a specific designed device (nano-reactor)
- Formation of small 'nano' bubbles ('cavities') with release of large magnitudes of energy over a small area (high energy density)



Typical velocity and pressure profile in a Nano Reactor

- Much more energy efficient than the acoustic cavitation process
- Suitable for larger scale, continuous processes

Applications of Nano Reactors®

Hydrodynamic cavitation

New technology with big potential in various applications

- **Process intensification (faster-higher yield-more efficient)**
- **Cell disruption (biotechnology)**
- **Microbial disinfection/destruction contaminants**
- **Other specific applications**

Use of Nano Reactors™ in Oil Processing

Ref : Gogate – Chemical Engineering and Processing 47 (2008),515-527

Nano Reactors®

- **Nano-reactor design**
  - ✓ Unique (patented) internal geometry
  - ✓ Originally developed as biodiesel reactor
  - ✓ Optimized design for use in oil processing

Proprietary design of CTi

- **What's happening inside the reactor ?**
  - ✓ High turbulence
  - ✓ Very high shear forces → **Very good contact**
  - ✓ Disruption of molecular agglomerates (e.g. : phospholipid micelles)
  - ✓ Faster and more efficient reactions (e.g. FFA neutralization)

A true reactor, not just a better mixer

Nano Neutralization™

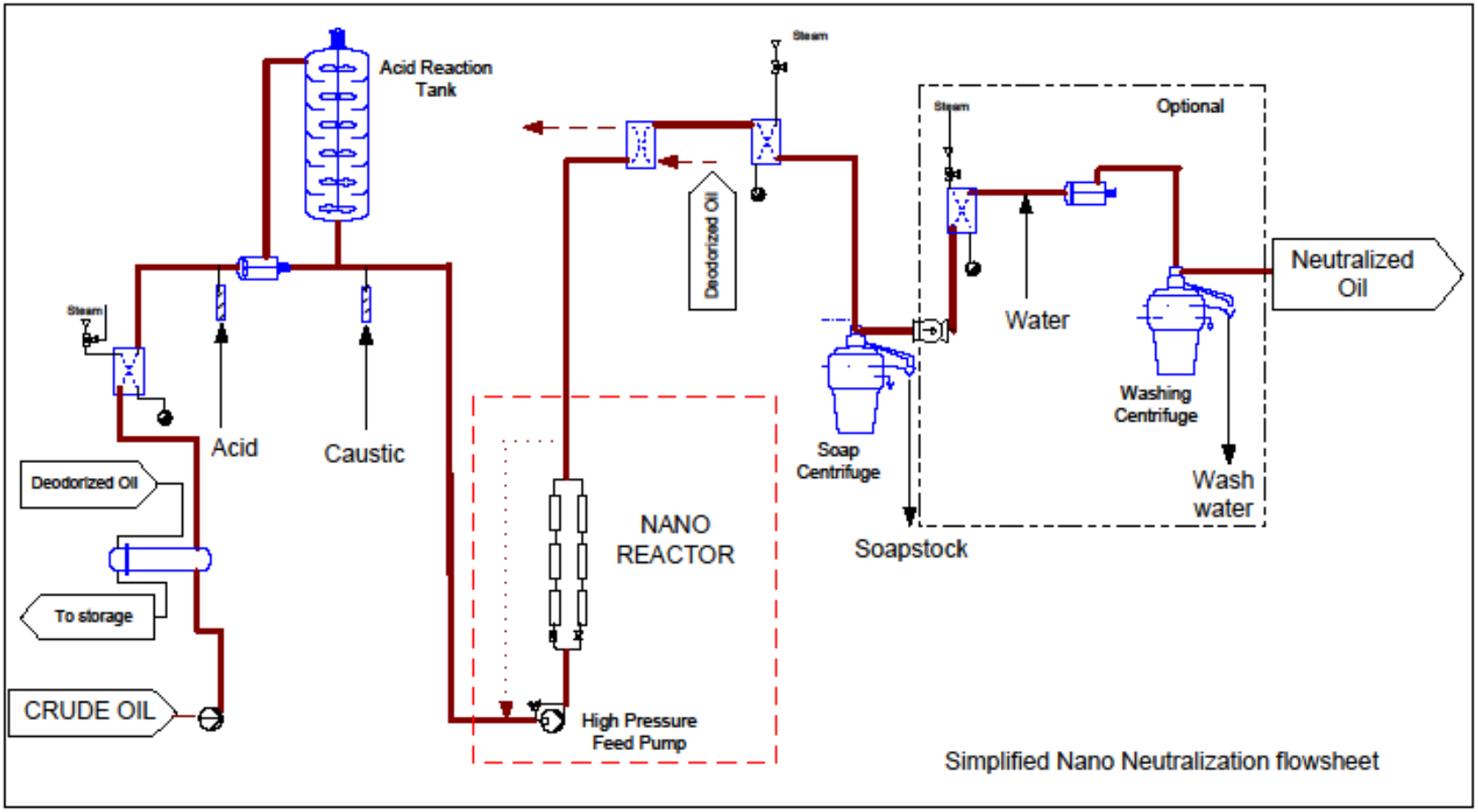
- ✓Patent pending process;
- ✓For new or existing chemical refining lines (add-on technology)
- ✓ 'next generation' chemical refining (more efficient/sustainable)
- ✓ Industrially proven on soybean oil
  - 400 TPD plant running > 1.5 year
  - Demonstrated process benefits (less chemicals, higher oil yield)
  - No mechanical issues (no internal fouling, easy operation)
- ✓Also applicable for chemical refining of all other soft oils
  - Successful pilot trials on rapeseed, sunflower, and corn oil
  - More industrial plants will start-up in near future (US, South America, Europe and India)

Nano Neutralization™

Typical process conditions

Temperature :	**45 to 75°C (115 to 170°F)**
	Also cold processing (10°C) gives good result
Pressure :	**55-75 bar (800-1100 psi)**
	No risk for emulsion formation (> 200 bar)
Maturation time :	**5 - 15 min**
	Longer maturation time not recommended
Energy consumption :	**2.5 – 4 kw/ton**
	Slightly higher than for Ultra High Shear Mixers (Silverson, IKA,….)

Nano Neutralization™



Nano Neutralization™ Reactors

Available industrial reactors

Lowest Reactor size : **10 gpm[1] = 50 TPD**

Medium Reactor size : **40 gpm = 200 TPD**

Highest Reactor size : **100 gpm = 500 TPD (developed, under evaluation)**

*** Multiple parallel reactors for unlimited capacity ranges**

Possible plant configurations, examples:

CAPACITY (TPD)	REACTOR CONFIGURATION
200	1 x 40 gpm reactor
400	2 x 40 gpm reactor
600	3 x 40 gpm reactor
800	2 x 400 TPD setup

[1]gpm : gallons per minute

Nano Neutralization™ Reactors

Complete skid mounted unit (400 TPD)

2 * 40 gpm reactor (400 TPD)

Nano Neutralization

400 TPD Nano Neutralization ™ of soybean oil - Industrial data – 1

Feedstock	Water-degummed soybean oil (120-170 ppm P; 0.45-0.55% FFA)	
	Nano Neutralization™	Classical caustic refining
Process parameters		
- Phosphoric acid (ppm)	**0-100**	**850-900**
- NaOH (% 16.6 °Be)	**0.7**	**1.2**
- Pressure (bar)	65	low
- Temperature (°C)[1]	50	70 to 80
Refined Oil Quality		
- P-content (ppm)	1-3	6-8
- Ca & Mg (ppm)	< 1	< 3
- FFA (%)	< 0.03	< 0.05
- Soaps (ppm)	< 100	200-300

[1] Temp. range : 50°C; oil heated to 80°C prior to centrifugation

Nano Neutralization™

600 TPD Nano Neutralization™ of soybean oil - Industrial data - 2

Feedstock	Water-degummed soybean oil (170 ppm P; 0.20% FFA)	
	Nano Neutralization™	Classical caustic refining
Process parameters		
- Phosphoric acid (ppm)	**26**	**750**
- NaOH (% dry basis)	**0.02**	**0.13**
- Pressure (bar)	65	low
- Temperature (°C)[1]	<50	70 to 80
Refined Oil Quality		
- P-content (ppm)	6	12
- Ca & Mg (ppm)	NA	NA
- FFA (%)	< 0.02	< 0.02
- Soaps (ppm)	< 50	<50

[1] Temp. range : <50°C; oil heated to 80°C prior to centrifugation

Nano Neutralization™: Proven advantages

- 0.2-0.4 % oil yield increase
- 90% less excess phosphoric acid
- 30-50% less caustic soda
- Lower soaps at primary separation
- Low to zero silica consumption

Nano Neutralization™ Explaining the benefits

BENEFITS	PROVEN SAVING	EXPLANATION
Less acid (phosphoric or citric)	90% less excess	Nano reactor destroys typical PL micelle structure As a result, non-hydratable PL become more hydratable with nearly no acid
Less caustic soda	Min. 30% less	Less caustic required for neutralisation of phosphoric acid; Less excess caustic for FFA neutralisation due to better mixing effect
No water wash Less silica Lower soaps in oil	Min. 50% less silica	Better phase separation because of less salts/soaps (less acid and caustic) gives lower soap content in once-refined oil (after first centrifuge)
Increased oil yield	0.2-0.4% yield increase	Less excess caustic gives less oil saponification and less neutral oil entrainment in soapstock Refining losses : (FFA+PL+MIV)* 1.35

Benefits are scientifically explained

Nano Neutralized *vs* conventional refined soybean oil

Comparison of industrial refined soybean oil samples

Quality Parameters	Soybean Oil (US Standard)	
	Industrial Nano-refined	Conventional Chemical refined
FFA (% C18:1)	0.02	0.02
P (ppm)	<1	<1
Fe (ppm)	<0.05	<0.05
Trans FA (%)	0.53	0.57
Color (R – $5^{1/4}$")	1.2	1.2
Tocopherols (ppm)	815	792
OSI (hr at 97.8°C)	15.5	15.7

Nano-neutralization™ improves refined oil quality

Pilot test unit

Containerized pilot unit for optimization trials in our R&D center

10 GPM reactors (smallest available)

Nano Reactor™ Applications

- ✓ **Industrial Scale Proven**
  - **Nano Neutralization™**
  - **Nano Degumming**

Under evaluation

- **Cold Nano Neutralization ™ (SFO)**
- **Nano washing (CPO)**
- **Enzyme assisted Nano Degumming (SBO, RSO, Canola)**
- **Nano Transesterification (biodiesel)**

Summary & Conclusions

✓ Nano-reactor™ is a new disruptive revolutionary technology in edible oil processing

✓ Successfully introduced in refining
(nano-neutralization™ and nano degumming)

✓ Truly 'next' generation process that meets all demands of oil processors

- More efficient (higher yield, lower operating cost)
- Improve oil quality (cold stability, color)
- More sustainable (less chemicals, no water washing, less adsorbents)

More info on
www.desmetballestra.com