Importance of BH & CH molasses characteristics in Ethanol Production

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RENEWABLE BIOMASS FUEL- A NEED OF THE HOUR

- One of the greatest challenges for society in the 21st century is to meet the growing demand for energy for transportation, heating and industrial processes, and to provide raw material for the industry in a sustainable way.

- In addition, the environmental deterioration resulting from the over- consumption of petroleum derived products, especially the transportation fuels, is threatening the sustainability of human society. Excessive consumption of fossil fuels, particularly in large urban areas, has resulted in generation of high levels of pollution during the last few decades.

- In this scenario, renewable sources such as wind, water, sun, biomass, geothermal heat can be the renewable sources for the energy industry whereas fuel production and the chemical industry may depend on biomass as an alternative source in the near future. All petroleum- based fuels can be replaced by renewable biomass fuels such as bioethanol, bio-diesel, bio-hydrogen, etc., derived from sugarcane, corn, switchgrass, algae, etc.

BIO FUEL-ETHANOL

- Bioethanol is regarded as one of the most promising bio fuels from renewable sources. It is used for medicines, cosmetics, and industrial materials and its production is increasing every year (Cardona & Sanchez, 2007). With increasing oil prices and global environmental concerns, bioethanol production has recently become a focus of attention.

- Ethanol is a volatile, flammable and colorless liquid that has a slight odor. In dilute aqueous solution, it has a somewhat sweet flavor, but in more concentrated solutions it has a burning taste. Ethanol has been made since ancient times by the fermentation of sugars. All beverage ethanol and more than half of industrial ethanol is still made by this process.,

ETHANOL

- Volatile,flammable,clear,colourless liquid.
- Good solvent.
- Used as a - Germicide,beverage,antifreez,fuel,depressant & chemical intermediate.
- Made by fermentation process of material containing sugar or from the compound which can be converted to sugar.
- Yeast enzyme readily ferment sucrose to ethanol.

ETHANOL-PHYSICAL & CHEMICAL PROPERTIES & CHEMICAL REACTION

Molecular formula- C_2H_5OH

Molecular weight- 46.07

Density- 0.791 at 20˚C

Boiling Point- 78.3˚C

Chemical Reactions:

- Main Reaction
- invertase $C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$
- zymase
- $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ $\Delta H = -31.2$ kcal
- Glucose Ethanol
- Side reaction
- $2\ C_6H_{12}O_6 + H_2O \rightarrow ROH + R'CHO$
- Fusel oil

ETHANOL-FEED STOCKS

Type of feed stock

1. Sugar based
2. Starchy material
3. Lignocellulosic

Example

1. Sugarcane Sugar beet
2. Molasses,Cane juice
3. Syrup Wheat,corn,barley
4. Wood,straw,bagasse

ETHANOL-FEED STOCKS

- Generally, bioethanol feedstock can be conveniently classified into three types which are sugar-based feedstock, starchy materials and lignocelluloses biomass .
- For this presentation, sugar-based feedstock- sugar cane molasses will be discussed as the feedstock.
- In particular, sugar-based feedstock contains readily available fermentable sugars and can be an ideal substrate for ethanol production by direct fermentation.
- Direct fermentation of sugars has advantages in production costs of ethanol, compared to processes that use starchy materials orlignocelluloses biomass as raw materials .

MOLASSES: AH,BH & CH

- Molasses is a viscous by-product of sugar cane process sugar beets into sugar.
- AH: AH or First molasses is what is left after the sugar has been crystallized out once.
- BH:When AH is re-boiled and more sugar crystallized out, the remaining syrup is second molasses(BH).
- CH : After a third time, the molasses is blackstrap molasses. Blackstrap is still the result of the final boiling, which is why it's less sweet and more strongly flavored and has a higher
- concentration of nutrients (such as iron and calcium) than other molasses. Molasses contains around 40% of sugar content that is fermented by yeast during the ethanol conversion process (Olbric, 2006).

MOLASSES: GRADES

- Molasses is a dark reddish colored jelly like viscous material. The pH of molasses varies from 5.5 to 7.5.
- The high osmotic pressure of molasses protects it from microbial spoilage, and it can be easily transported by tankers. Molasses can be pumped easily.
- Molasses may be the best suitable raw material for fermentation.
- Molasses are classified into following grades (IS 1162-1958)
  a) First grade Molasses: It contains min 50% total reducing sugar (TRS),Max 14% Sul ash /100 Bx & Min 85 Deg Brix at 27.5 Deg C.
  b) Second grade Molasses: It contains min 44%total reducing sugar (TRS),Max 17.5% Sul ash/100 Bx & Min 80 Deg Brix at 27.5 Deg C
  c) Third grade Molasses: It contains min 40% total reducing sugar
- (TRS),Max 17.5%Sul ash/100 Bx & Min 80 Deg Brix at 27.5 Deg c.

ETHANOL FROM CANE MOLASSES

Molasses is generally used because it is rich in all salts except nitrogen which is normally employed in the actual growth of yeast cells. Molasses is defined as waste product of sugar industry of which further extraction of sugar is uneconomical, contains about 40– 50% fermentable sugars. Because of the ease with which this can be fermented into ethanol and its low price have made this raw material ideal for ethanol production.

JUICE/SUGAR/SUGAR SYRUP-BH-CH ROUTES & INDIAN GOVT POLICY

REVISED ETHANOL PRICES FOR ESY (Ethanol supply year)20-21				
Rs./Ltr	ESY 19-20	ESY 20-21	DIFFERENC E	% INCREASE
C-HEAVY	43.75	45.69	1.94	4.4
B-HEAVY	54.27	57.61	3.34	6.2
JUICE/sugar/sugar syrup	59.48	62.65	3.17	5.3

BH & CH – MOLASSES QUANTITITIES

- The quantity of CH molasses produced is in the range of 3% to 4.5 %cane(In refined sugar phosphotation process) & 4.50% to 5.50 % cane in sulphitation process. The quantity of BH molasses is in range of 5.50% to 7.50 in sulphitation units and 4.75 % to 6.00% in raw sugar production units .

- The quantities of molasses produced is largely dictated by the amount of non sucrose in the raw juice entering the factory. A small part of the may be eliminated in clarification, and some additional nonsucrose may be formed by degradation reaction s in the process.

All this impurity exits in the molasses stream; the larger the amount of nonsucrose, the greater is the quantity of molasses.

BH & CH -Characteristics

The characteristics of molasses is very variable, depending on the efficiency of exhaustion in the factory (which affects the sucrose content), the area and time of year of harvest (which dictate the nonsucrose components) and the conditions in the factory that have resulted in the elimination or the generation of nonsucrose components. By comparison with beet, cane has a higher reducing sugar content and a lower sucrose content.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION

- Brix
- TRS
- UFS
- FS
- Total solids
- Total suspended solids
- Total dissolved solids

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION

- Sulphated ash
- Inorganic ash
- Calcium content
- Sludge content
- Specific gravity
- PH
- Total bacterial count

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION BRIX

BRIX	**High Brix**
	*Restrict Yeast Mobility
	*sugar concentration low.
	*High solids.
	*low alcohol production
	* High slop generation.
	Low Brix (With high TRS)
	* Yeast works properly
	Depends upon sugar concentration.
	* Low solids.
	* Alcohol production depends on sugar concentration.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION TRS

T.R.S	**High T.R.S** %
	* High alcohol production.
	* High recovery.
	* low solids.
	* Low slop generation.
	* Low chemical consumption.
	* Low effluent generation .
	* Low steam factor.
	Low T.R.S %
	* High solids.
	* High slop generation.
	* Low recovery.
	* Low alcohol production.
	* High steam factor.
	* More chemical consumption.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION UFS & FS

Un- fermentable sugar	**High U.F.S%**
	* Low fermentable sugar.
	*low alcohol production
	* low recovery.
	* High Unfermentable solids.
	* High slop generation.
	Low U.F.S%
	*High production.
	* High Recovery.
	* low solids.
	* Low slop generation.
	*Good for fermentation process
Fermentable sugar	*Consumed by yeast cell.
	* F.S directly proportional to fermenter efficiency

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION TOTAL SOLIDS,TSS & TDS#

Total solid	High solids
	*High slop generation.
	*Low alcohol %
	*Setup of fermentation goes high.
	Low solids
	*Slop generation low.
	Setup of fermentation goes low.
Total suspended solid	*Solids can be trapped by filter paper.
	* High TSS molasses produe more sludge.
	*High TSS can affects the motion of yeast cell.
Total Disolved Solid	* TDS denotes inorganic salts and organic matter present in molasses.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION SULPHATED , INORGANIC ASH , CALCIUM & SLUDGE

Sulphited Ash in molasses	* It depends on the non volatile inorganic impurities in molasses.
	*High amount of inorganic impurities effects the growth and viabilty of yeast cells.
In-organic Ash contents in molasses	*Due to inorganic contents.
	*Not good for yeast health.
Calcium estimation in molasses	* High calcium content reduce cell growth & viability.
Sludge content in molasses	*High sludge production have Harmful affect on yeast propagation.
	*clumping in yeast cells arise.
	* High Slop Generation.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION SP.GRAVITY,PH

Specific gravity of raw molasses	*Specific gravity depends on sugar content and the solids presents in it.
	* High specific gravity means high solid content.
	* setup of fermenter goes high due to high specific gravity.
	* In high specific gravity molasses, yeast does not work properly.
PH of the molasses	*Molasses has an acid pH, range approx 5 to 5.5.
	* pH 4.2-4.5 is batter for good alcoholic fermentation for yeast activity.
	*High pH of molasses increases acid formation such as acetic acid and lactic acid which prohibit the growth of yeast.

BH & CH- IMPORTANT CHARACTERISTICS AFFECTING ETHANOL PRODUCTION TVA,TOTAL BACTERIAL COUNT

T.V.A	*TVA denotes the contamination of molasses.
	* High TVA affects fermentation efficiency.
	*Reduce yeast activity.
Total Bacterial count in molasses	*High Bacterial counts directly affect fermentation efficiency.
	* Produce more acids.
	* Effects on the activity of yeast.

BH & CH–ACTUAL ANALYSIS & OPERATIONAL RESULTS

B-HY VS CH							
Sr.no	Particulars	Unit	C-HY		B-HY		
1	TRS	%	42.00	44.00	52.00	55.00	59.00
2	UFS	%	4.50	5.50	3.80	3.60	3.40
3	FS	%	37.50	38.50	48.20	51.40	55.60
4	ALCOHOL	%	8.00	10.00	11.50	12.00	12.50
5	RECOVERY	KL/TON	0.21	0.22	0.28	0.30	0.33
6	QUANTITY PRODUCE	KL	100.00	100.00	100.00	100.00	100.00
7	MOLASSES DISTILLED	TON	469.98	452.69	355.66	331.70	306.65
8	SPENT WASH GENRATION	KL	1009.04	765.23	642.81	611.02	582.18
9	MOLASSES BRIX	DEG	88.00	87.00	86.00	85.00	84.00

ANALYTICAL TECHNIQUES INVOLVED IN MEASUREMENT OF MOLASSES

- Ph – PH meter
- Dissolved solids- Brix hydrometer is most common as Refract meter overestimates true solid by 2% and vacuum oven drying gives 2.5 units below RDS.
- Pol- Polarimeter by lead clarification(gives underestimatated loss in molasses)
- Sucrose- ICUMSA method GS4/7-1(Double polarization or Clerget T) & GC

ANALYTICAL TECHNIQUES INVOLVED IN MEASUREMENT OF MOLASSES

- Total sugar- most important quality criteria in molasses trade and is measured by ICUMSA method GS4/3-7 after hydrolysis.

- RS-*Maillard reactions* occurring in processing lead to substances being formed which register in a reducing sugars determination, but do not ferment in alcohol production. The content of so-called unfermentable reducing substances is higher in final molasses than in A or B molasses. *Rein and Smith (1981) showed that the reducing* sugars content, most often measured by the *Lane* and *Eynon method, ICUMSA Method GS4/3- 3*(Anon. 2005), overestimates monosaccharide in molasses sample by 34%.

- GC Provides a more accurate measurement of Sucrose,Glucose,Fructose & fermentable sugars in molasses.

CONCLUSION

Considering importance of various characteristics of molasses (BH&CH) in production of molasses, it is a need of the hour to include techniques like Gas chromatography in routine analysis of molasses.

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THANK YOU