ISSN No:-2456-2165

Assessment of Solvent Selection on Health, Safety and Environment Impact of Formulated Demulsifiers

F. Airiagbonaye, O. Achugasim, and O. Akaranta
Africa Centre of Excellence on Oilfields Chemical Research (ACE-CEFOR)
University of Port Harcourt

Abstract:- This paper seeks to quantify the effect of solvents on Health, Safety and Environment (HSE) impact in formulated demulsifiers using Chemical Scoring Index (CSI). The CSI is based on the three-hazard categories defined by United Nations' Globally Harmonized System for Classification and Labeling of Chemicals (GHS) for defining greener chemicals. Chemical components of each solvent selected for use in the demulsifier's formulation were quantified by scoring the level of hazard posed by the component in relation to its percentage composition in the product. a carcinogen in a 10% component of a product will be scored higher than in a 1% composition. Additionally, a 'carcinogen' is weighted higher than an 'irritant'. As such, solvents with low CSI within same usage group are considered to have lower intrinsic hazard and therefore used in selecting best HSE green solvent. Five (5) solvents were quantified; namely: Xylene, Naphta, Diesel Fuel, Methanol and Butanol. 'Butanol' was considered best HSE solvent with a CSI of '230', while 'Xylene' was the least HSE chemical with CSI of '420'. It is recommended that rather than focus on performance and cost of a chemical product only, it is essential to consider the Health, Safety and Environment impact in the formulation of oilfield chemical products. This model will assist HSE professionals in quick assessment of safer chemicals alongside their performance. Furthermore, usage of greener solvent should be considered and at lower percentage of the chemical formulations.

Keywords:- *Flavonoids, Demulsifers, Green chemicals, Solvent.*

I. INTRODUCTION

Solvents are typically used in most chemical formulations and reactions, but they are not the active components in these formulations. Byrne et.al(2016) reported that use of toxic, flammable or environmentally damaging solvents should be avoided since these characteristics have no impact on the function of the systems they are applied. Amid the functionality of solvents in recovery, polarity and purification, their negative effects in air pollution and impact on human must also be considered. Ashcroft et.al (2015) reported that amide solvents have high polarity necessary to dissolve a broad range of substrates and accelerate reactions. On the other hand Buhler and Reed (1990) reported that amide solvents are linked with reproductive toxicity. Although several measures have been put in place to prohibit and restrict the use of highly dangerous chemicals; selection and substitution for greener chemicals are advised.

The European regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), gave some restriction to the use of toluene, chloroform and Dichloromethane (DCM). The hazards highlighted are that; toluene is suspected to damage unborn child and organs through prolonged exposure, while DCM and chloroform are suspected to cause cancer.

Capello et.al (2007) defined 'green solvent' on a two tired assessment of health, safety and environment(HSE) impacts and the net cumulative energy demand(CED), that the solvent with the lesser scores is indicative of greener solvent in comparison to solvent in same usage group. This HSE profiling of hazards in a chemical can be applied to any solvent in a process for selection of Greener solvents. Byrne et.al (2016) using HSE hazard profiling, reported that alcohols and esters were greener than hydrocarbons, which inturn were better than formaldehyde and dioxane.

In meeting operating performances, large portfolios of chemicals are used by production companies. In oil exploration and production companies in particular, catalogues of chemicals exist for their various operations, namely: drilling, completion, stimulation, workover and production of their wells. Demulsifiers are one of the frequently used chemicals in the oil and gas industries. Demulsifiers comprise of various chemical formulations used in breaking water-in-oil/oil-in-water emulsions.

Emulsion problems in oil and gas industries can lead to high operating/capital cost, corrosion, frequent breakdown of processing units and out of specification products hence must be eradicated. Abedini and Mosayebi(2013), reported that the volume of dispersed water in emulsions, occupies space in the processing equipment and pipelines. Moreso, emulsion causes changes in the characteristics and physical properties of crude oil. Foxenberg et.al (1998) reported that stable water-in-crude oil emulsions, characterized by high viscosity and rigid film can cause significant formation damage to the reservoirs.

Oil and gas companies often make use of chemicals in solving their operational problems and meeting their production goals. They are also under stringent obligations to comply with all legislation set by regulatory authorities, environmental groups and stakeholders.

ISSN No:-2456-2165

Oil and Gas companies are mandated to manage all chemicals, products and by-products' hazards to As Low as Reasonably Practicable (ALARP). This means imbibing the culture of Product and Environmental Stewardship.

Verslycke et al (2014), reported that a broad spectrum of chemicals exhibit wide range of potential hazards to human health, physical safety and the environment (HSE). They further, explained that; performance and cost were historically the primary criteria for chemical selection. Sanders et al (2010) also reported that the primary criteria for chemical selection were cost and performance.

The entrance of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) in 1990 added criteria for Environmental hazards in product development and selection.

In meeting five (5) of the Sustainable development goals of ; Good health and well-being, Clean water and sanitation, climate action, life below water and life on land, companies and professional have the responsibility of developing safer products by ensuring that HSE standards are prioritized in chemical selection processes. This would in a long run effectively reduce the inherent impacts of these chemicals, meet and exceed our production performances and make the earth conducive for all.

The HSE hazards can be quantified by scoring the various chemical components in each formulation using the three-hazard categories defined by United Nation's Globally Harmonized System for Classification and Labeling of Chemicals (GHS).

Knowing the HSE risks contributed by each chemical component will aid in improving the production and replacement of high HSE risk component with less HSE impacting chemical of same function or with a diluted one.

Sanders et al (2010), further reported the replacement of three (3) of Halliburton's chemical products through the knowledge of CSI with chemicals of lower HSE risks that performed just as good as the former. CSI rating of hazards helped Halliburton to replace chemicals produced in the 70s and 80s with better and safer chemicals in recent years.

It is worth noting that CSI scores must be equated with price and performance of the product in selecting the qualify candidate for the operation.

This paper documents quantification of HSE hazards in five(5) solvents used in demulsifiers formulation. The five(5) solvents comprise of three(3) hydrocarbons-one(1) aliphatic and two(2) aromatics and two(2) alcohols.

The GHS hazard categories and ratings gave the guidelines, while the chemical scoring index was chosen for scoring and ranking each hazard categories. The screening of the three major hazard categories(Physical, Health and Environmental) was carried out in all five(5) solvents. The best performing HSE/safe solvent would be selected based on overall lowest CSI score for all three(3) hazard categories. Thereafter, the best solvent for the operation will be selected from bottle test result-the product with the highest water dropout; low cost and low HSE impact.

II. METHODOLOGY

Five (5) different solvents for demulsifier formulations were analysed for their HSE impacts. Major hazards of interest were selected from the three (3) categories of hazards based on GHS (Physical, Health and Environmental). Tables 1.1, 1.2, and 1.3, gives the various categories of Environmental, Health and Physical Hazard criteria respectively in GHS.

The selected hazards of interest and levels were extracted from each chemical component's Safety Data Sheets (SDS). Thereafter a weighted score was assigned from the CSI to each hazard in relation to the percent availability of the chemical component in the measured demulsifier. Tables 2.1, 2.2 and 2.3 give the CSI weighted scores assigned to the health, physical and environmental hazard categories respectively in relation to the percent availability of the chemical component in the measured product.

CSI, assigned weighted scores to various hazards based on the categories, percent composition and level of harm for instance 'carcinogen' is weighted ten times higher than an irritant'.

A computation template is drawn as seen in table 3.0, this is to aid in accurate record of required information from the SDS and appropriately assign the correct score to each component in the products. The scores of each hazard category for all contributing components in a product are then summed up to achieve the CSI for each hazard category in the product.

To calculate the total CSI for HSE risk in a product, the computed values from the physical, environment and health CSIs for the product in question are then added together.

To then select the best demulsifier for the operation, the chemical performance and cost them comes into play amongst the less HSE risk product. To achieve this, 'bottle test' analysis was then carried out, by rating the percent water dropout by each demulsifier on treatment of emulsion from a known field with emulsion problem.

ISSN No:-2456-2165

Table 1.1 GHS Basic Environmental Hazard Criteria

Categories	**Category 1**	**Category 2**	**Category 3**
ACUTE AQUATIC TOXICITY			
96hr LC50(for fish)	≤ 1mg/l	>1 but ≤ 10mg/l	>10 but ≤ 100mg/l
48hr EC50(Crustacea)	≤ 1mg/l	>1 but ≤ 10mg/l	>10 but ≤ 100mg/l
72hror 96hr ErC50(for Algae or other aquatic plants)	≤ 1mg/l	>1 but ≤ 10mg/l	>10 but ≤ 100mg/l
CHRONIC AQUATIC TOXICITY			
Chronic NOEC or EC_X (for fish)	≤ 0.1mg/l	≤ 1mg/l	Not Applicable
Chronic NOEC or EC_X (for Crustacea)	≤ 0.1mg/l	≤ 1mg/l	Not Applicable
Chronic NOEC or EC_X (for Algae or other aquatic plants)	≤ 0. 1mg/l	≤ 1mg/l	Not Applicable
OZONE DEPLETION	≥ 0.1mg/l	Not Applicable	
Bioaccumulation Potential	BCF>500 or if absent log Kow > 4		
Rapid Degradability	> 70% in 28days		

Table 1.2 GHS Health Hazard Criteria

Categories	**Category 1**		**Category 2**	**Category 3**	**Category 4**
CARCINOGENICITY (≥ 0.1%)	**CAT 1A (Known)**	**CAT 1B (Presumed)**	**CAT 2 (Suspected)**	NOT APPLICABLE	NOT APPLICABLE
ACUTE TOXICITY					
ACUTE ORAL TOXICITY (mg/kg body weight)	**5**		50	300	2000
ACUTE DERMAL TOXICITY (mg/kg body weight)	50		200	1000	2000
ACUTE INHALATION TOXICITY (Gases(ppmV)	100		500	2500	20000
ACUTE INHALATION TOXICITY (Vapours(mg/l)	0.5		2.0	10	20
ACUTE INHALATION TOXICITY (Dust and Mists(mg/l)	0.05		0.5	1.0	5
CORROSIVITY (IRRITANT)	**≥ 5%**		≥ 1% but < 5%	≥ 10%	NOT APPLICABLE

ISSN No:-2456-2165

Table 1.3 GHS Physical Hazard Criteria

Categories	Category 1	Category 2	Category 3	Category 4		
EXPLOSIVE	Division 1.1	Division 1.2	Division 1.3	Division 1.4	Division 1.5	Division 1.6
FLAMMABLE GAS(at 20^{0}C and 101.3kPa)	Ignites in ≤13% mixture with air	Have a flammable range with air mixture	Not Applicable			
FLAMMABLE LIQUID (flash point)	< 23^{0}C; Initial B.pt < 35^{0}C	< 23^{0}C; Initial B.pt >35^{0}C	≥23^{0}C and ≤60^{0}C	> 60^{0}C and ≤ 93^{0}C		Not Applicable
FLAMMABLE SOLID(Burning rate test)	Wetted zone does not stop fire and Burning rate >2.2mm/s	Wetted zone stops fire at least 4mins and Burning rate>2.2mm/s	Not Applicable			
OXIDIZING LIQUID	Mean pressure rise < 1:1 by mass of 50% perchoric acid and cellulose	Mean pressure rise time of 1:1 mixture by mass of 40% aqueous sodium chlorate and cellulose	Mean pressure rise time of 1:1 mixture by mass of 40% aqueous nitric acid and cellulose	Not Applicable		
SELF-REACTIVE SUBSTANCE	Type A	Type B	Type C& D	Type E & F	Type G	
SELF-HEATING SUBSTANCE	+VE test on 25mm sa	-VE test on 25mm but +VE on 100mm sample cube at 140^{0}C	Not Applicable			
EMIT FLAMMABLE GASES IN CONTACT WITH WATER	Reacts vigorously and gas evolution rate of ≥10litres/kg of substance over any 1min	Reacts readily and maximum gas evolution rate of ≥20litres/kg of substance per hour	Reacts slowly and maximum gas evolution rate of ≥1litres/kg of substance per hour	Not Applicable		

Table 2.1 CSI WEIGHTED SCORES FOR HEALTH HAZARDS

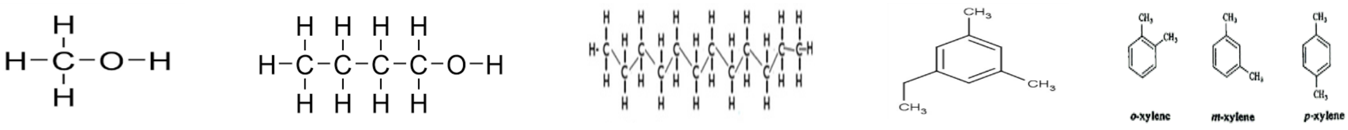
Hazard Categories\ Percent Component Available	Maximum CSI Scores	>0%-0.09%	0.1%-0.9%	1%-4.9%	5%-9.9%	10%-29.9%	30%-59.9%	60%-100%
		CSI WEIGHTED SCORES						
NO DATA AVAILABLE	100	10	25	50	75	100	do not evaluate	do not evaluate
CARCINOGENICITY CAT.1	100	25	100	100	100	100	100	100
CARCINOGENICITY CAT.2	75	10	75	75	75	75	75	75
ACUTE TOXICITY CAT.1	100	10	25	50	75	75	100	100
ACUTE TOXICITY CAT.2	75	5	10	25	50	50	75	75
ACUTE TOXICITY CAT.3	50	0	1	5	10	25	50	50
ACUTE TOXICITY CAT.4	10	0	0	1	5	5	10	10
MUTAGENICITY	50	10	25	25	50	50	50	50
REPRODUCTIVE TOXICITY	50	10	25	40	50	50	50	50
ACUTE TARGET ORGAN TOXITY	50	1	5	10	25	25	50	50
CHRONIC TARGET ORGAN TOXITY	50	1	5	10	25	25	50	50
SENSITIZERS	25	5	10	25	25	25	25	25
CORROSIVITY CAT.1	25	0	1	5	5	10	25	25
CORROSIVITY CAT.2(IRRITANT)	10	0	0	0	5	5	10	10
ASPIRATION HAZARD	10	0	0	0	1	5	10	10
NO HAZARD	0	0	0	0	0	0	0	0

Table 2.2 CSI WEIGHTED SCORES FOR PHYSICAL HAZARDS

Hazard Categories\ Percent Component Available	Maximum CSI Scores	>0%-0.09%	0.1%-0.9%	1%-4.9%	5%-9.9%	10%-29.9%	30%-59.9%	60%-100%
		CSI WEIGHTED SCORES						
NO DATA AVAILABLE	50	0	5	10	25	50	Do not Evaluate	Do not Evaluate
EXPLOSIVE	100	25	75	100	100	100	100	100
ORGANIC PEROXIDE	100	5	10	75	75	100	100	100
FLAMMABLE GAS	75	5	10	25	50	75	75	75
FLAMMABLE LIQUID CAT.1	75	0	5	10	25	50	75	75
FLAMMABLE LIQUID CAT.2	50	0	1	5	10	25	50	50
FLAMMABLE LIQUID CAT.3	25	0	0	1	5	10	25	25
FLAMMABLE LIQUID CAT.4	10	0	0	0	1	5	10	10
FLAMMABLE SOLID	75	1	5	50	75	75	75	75
OXIDIZING GAS	75	5	10	25	50	75	75	75
OXIDIZING SOLID	75	1	5	50	50	50	75	75
PYROTECHNIC	75	5	10	25	50	75	75	75
PYROPHORIC(LIQUIDS AND SOLID	75	1	5	10	25	50	75	75
OXIDIZING LIQUID	50	0	1	5	10	25	50	50
SELF-REACTIVE SUBSTANCE	50	0	1	5	10	25	50	50
GASES UNDER PRESSURE	25	1	5	25	25	25	25	25
SELF-HEATING SUBSTANCE	10	0	0	1	1	5	10	10
EMIT FLAMMABLE GASES IN CONTACT WITH WATER	10	0	0	1	1	5	10	10
CORROSIVE TO METALS	5	0	0	1	1	5	5	5
NO HAZARD	0	0	0	0	0	0	0	0

Table 2.3 CSI WEIGHTED SCORES FOR ENVIRONMENTAL HAZARDS

Hazard Categories\ Percent Component Available	Maximum CSI Scores	>0%-0.09%	0.1%-0.9%	1%-4.9%	5%-9.9%	10%-29.9%	30%-59.9%	60%-100%
		CSI WEIGHTED SCORES						
Hazard Categories		>0%-0.09%	0.1%-0.9%	1%-4.9%	5%-9.9%	10%-29.9%	30%-59.9%	60%-100%
NO DATA AVAILABLE	100	10	25	50	75	100	Do not Evaluate	Do not Evaluate
ACUTE AQUATIC TOXICITY CAT.1	100	1	5	10	25	50	75	100
ACUTE AQUATIC TOXICITY CAT.2	75	0	1	5	10	25	50	75
ACUTE AQUATIC TOXICITY CAT.3	50	0	0	1	5	10	25	50
OZONE DEPLETION	50	5	10	50	50	50	50	50
VOLATILE ORGANIC COMPOUNDS	50	5	10	50	50	50	50	50
HAZARDOUS AIR POLLUTANTS	50	1	5	10	25	40	50	50
HAZARDOUS WATER POLLUTANTS	50	1	5	10	25	40	50	50
BIODEGRADATION -Persistent	50	5	10	50	50	50	50	50
BIODEGRADATION- Inherent	10	1	10	10	10	10	10	10
BIOACCUMULATION	50	5	10	50	50	50	50	50
ENDOCRINE DISRUPTORS	50	10	25	50	50	50	50	50
NO HAZARD	0	0	0	0	0	0	0	0



Methanol Butanol Diesel Fuel Naptha Xylene

Fig 1:- Chemical Structures of Solvents used in Demulsifier Formulation

ISSN No:-2456-2165

III. RESULTS AND DISCUSSION

The quantified hazard scores of the five (5) solvents are shown in Tables 3.1, 3.2, 3.3, 3.4 and figures 2, 3, 4, and 5. Table 3.0 is a sample of the computation table, showing the hazard categories and how the various scores for each solvent were reached. Fig. 5 also shows how each hazard categories contributed to the total HSE hazards CIS for each product-the major scores is observed to be on health risks.

HSE risks from 'butanol' solvent was calculated as having lowest HSE impact with a total CSI score of '230', while 'xylene' solvent was calculated as having the highest HSE impact with total CSI score of '470' as shown in table 3.1, figs.2 and 6. The obtained values showed that scores increased from solvents with alcohol structure (Butanol and Methanol) through the aliphatic group (Diesel fuel) to the solvents with benzene structure (Naptha and Xylene). Fig. 1 displays the chemical structures of the solvents under review. This finding corroborates Byrne et.al (2016) findings that alcohols are greener than hydrocarbons.

The reviews of the individual hazard categories contributing to the total HSE risk CSI, played out in a different trend as shown in tables 3.1- 3.4 and figs 2 – 6. The product with least total HSE CSI score was not necessarily the least in all the individual hazard categories. The exception of health hazard scores-which was the defining HSE risks, it maintained same position with the total scores.

As shown on table 3.2, in environmental risks, the alcohol solvents were seen to have a zero score, this is adduced to their ability to readily biodegrade, miscible and low melting point. This also agrees with Agarwal (2006) and Surisetty et.al (2011) who proposed butanol as an alternative fuel because they are environmentally friendly. Next to the alcohol was the diesel fuel with CSI of '75'.

The fact remains that one of the limiting factor in CSI computation is insufficient data in the SDS. This limitation could affect the HSE risk computation; hence high values would be slammed on those components as prescribed by CSI guideline.

In same line of reasoning, in table3.4 and fig 5, comparison of the physical hazards CSI scores, naphtha solvent which ranked fifth(5^{th}) in overall HSE impact was observed to be the best on physical hazards with a CSI score of '10'. Butanol followed with a CSI score of '25', while methanol had a CSI of'50' because of its high flammability. The major hazard considered in the physical hazard category was flammability because of its high relativity to risk of fire.

On comparison of health hazard scores in Table 3.3 and Fig.3, health hazards being the highest contributory hazard to the overall CSI score. A trend was observed that the health risk increased from solvent with alcohol structure to benzene structure.

It is worth noting that butanol though with longer hydrocarbon chain was calculated greener than methanol. Patocka and Kuca(2012) reported that, methanol is rapidly absorbed from gastric mucosa, and achieves a maximal concentration 30-90 minutes after ingestion'. This can be adduced to the physicochemical properties of both alcohols. Methanol being more readily soluble than butanol will cause quicker damage.

Table 5.0 shows the commulative effect of a solvent in a demulsifier. Demulsifier A and B are same modifying chemicals but dissolved in xylene and butanol respectively. Demulsifier A gave a CSI of '987', while Demulsifier B had a CSI of '647'. This is about 35% off the HSE risks posed by using xylene as a solvent

In considering the best solvent for operational with less HSE risks and excellent performance, demulsification bottle test was carried out. Fig.7 and 8 displayed the effectiveness of each demulsifiers in water seperation from the emulsion at room temperature and 60^0C the average operating condition of a separator in the oilfield respectively. The result showed butanol to be better solvent for Modified Flavonoid demulsifier . In aggregate butanol is best performing in HSE and effective in demulsification of water in crude oil emulsion.

Table 3.0 Computation of HSE Hazards and Weighted Scores

PRODUCT	XYLENE										
COMPONENTS	XYLENE	ETHYLBENZENE		Fuels, diesel;		Solvent Naphtha		METHANOL		N-BUTANOL	
CAS NO.	1330-20-7	100-41-4		68334-30-5		64742-94-5		67-56-1		71-36-3	
CONCENTRATION%	> 90 -< 100	> 25 - < 30%		≥90- ≤100		60-100%		40-50%		30-40%	
ENVIRONMENTAL HAZARD											
ACUTE /CHRONIC AQUATIC TOXICIT	CAT3		50	CAT.2	75	CAT.2	75	28200mg/l	0	1840mg/l (	0
BIODEGRADATION-	NO DATA		50	Readily biodegradable	0	NO DATA	75	yes	0	92% Readily degradable	0
			100		**75**		150		**0**		0
HEALTH HAZARD											
CARCINOGENICITY	CAT 1	CAT 1	100	CAT. 2	75	yes 2	75	NOT LISTED	0	no present	0
ACUTE ORAL TOXICITY	CAT4	CAT4	10	CAT.4>500	10	>70500mg/	10	CAT. 3	50	CAT.4	10
ACUTE INHALATION TOXICITY	CAT4	CAT4	10	11mg/l CAT	50	5100ppm (	50	CAT. 3	50	CAT.4	10
ACUTE DERMAL TOXICITY	CAT2	CAT2	75	CAT 2	75	>2000mg/k	10	CAT. 3	50	CAT.4	10
ACUTE EYE TOXICITY	CAT.2	CAT.2	75	CAT 4	10	CAT 4	10	CAT. 4	10	CAT.2	75
ACUTE/CHRONIC TARGET ORGAN T	CAT.2	CAT.3	50	CAT.2	10	CAT 3	75	CAT. 1	50	CAT.2	50
			320		**230**		**230**		**210**		155
PHYSICAL HAZARD											
FLAMMABLE LIQUID	CAT.3	CAT2	50	CAT.3	25	CAT.4	10	CAT.2	50	CAT.3	25
			50		**25**		10		**50**		25
			470		330		390		260		180

Table 3.1 TOTAL HSE HAZARDS SCORES

SAMPLE DESCRIPTION	CSI SCORE	POSITION
XYLENE	470	**5TH**
DIESEL FUEL	330	**3RD**
NAPHTA	390	**4TH**
METHANOL	260	**2ND**
BUTANOL	230	**1ST**

Table 3.2 ENVIRONMENTAL HAZARDS' CSI SCORES

SAMPLE DESCRIPTION	CSI SCORES	POSITION
XYLENE	100	4TH
DIESEL FUEL	75	3RD
NAPHTA	150	5TH
METHANOL	0	1ST
BUTANOL	0	1ST

Table 3.3 HEALTH HAZARDS' CSI SCORES

SAMPLE DESCRIPTION	CSI SCORES	POSITION
XYLENE	320	5TH
DIESEL FUEL	230	2ND
NAPHTA	230	3RD
METHANOL	210	2ND
BUTANOL	155	1ST

ISSN No:-2456-2165

SAMPLE DESCRIPTION	CSI SCORES	POSITION
XYLENE	50	4TH
DIESEL FUEL	25	2ND
NAPHTA	10	1ST
METHANOL	50	4TH
BUTANOL	25	2ND

Table 3.4 PHYSICAL HAZARDS' CSI SCORES

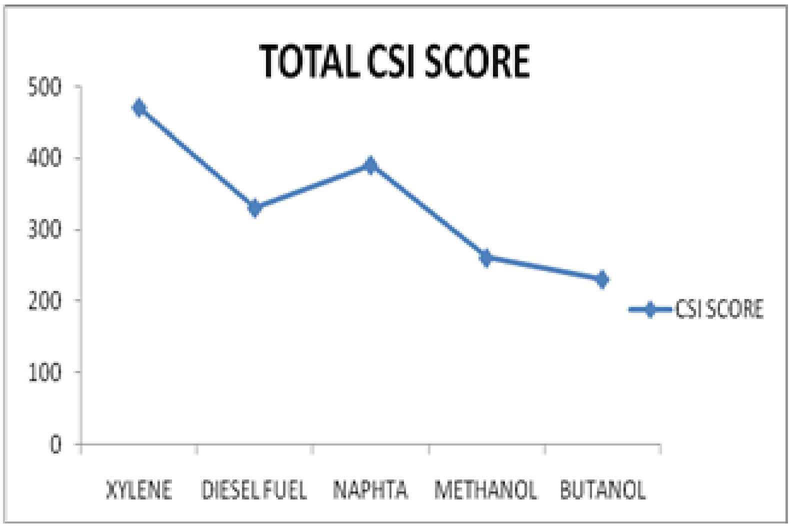


Fig 2:- Comparison of Total CSI HSE Hazards score

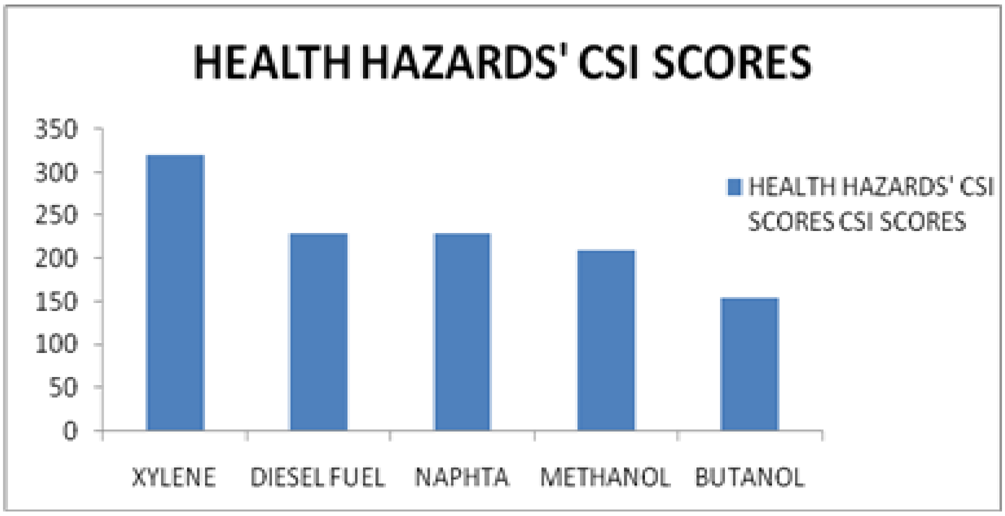


Fig 3:- Comparison of Health Hazards' score

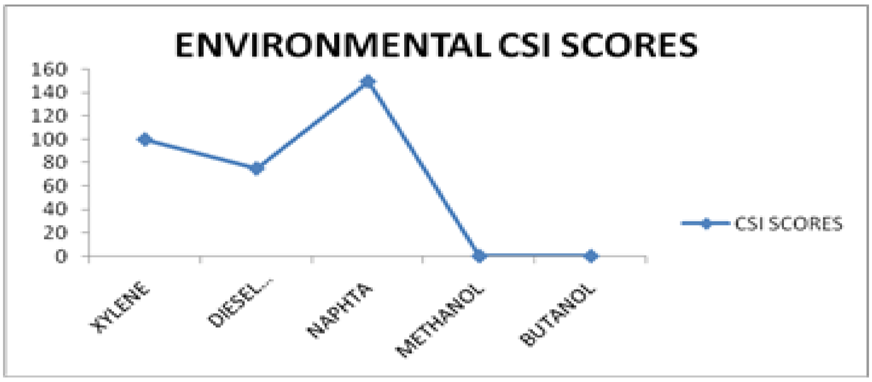


Fig 4:- Comparison of Environmental Hazards' score

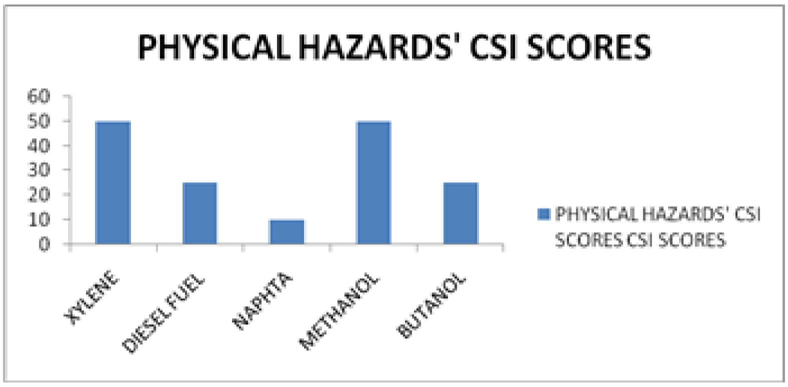


Fig 5:- Comparison of Physical Hazards' score

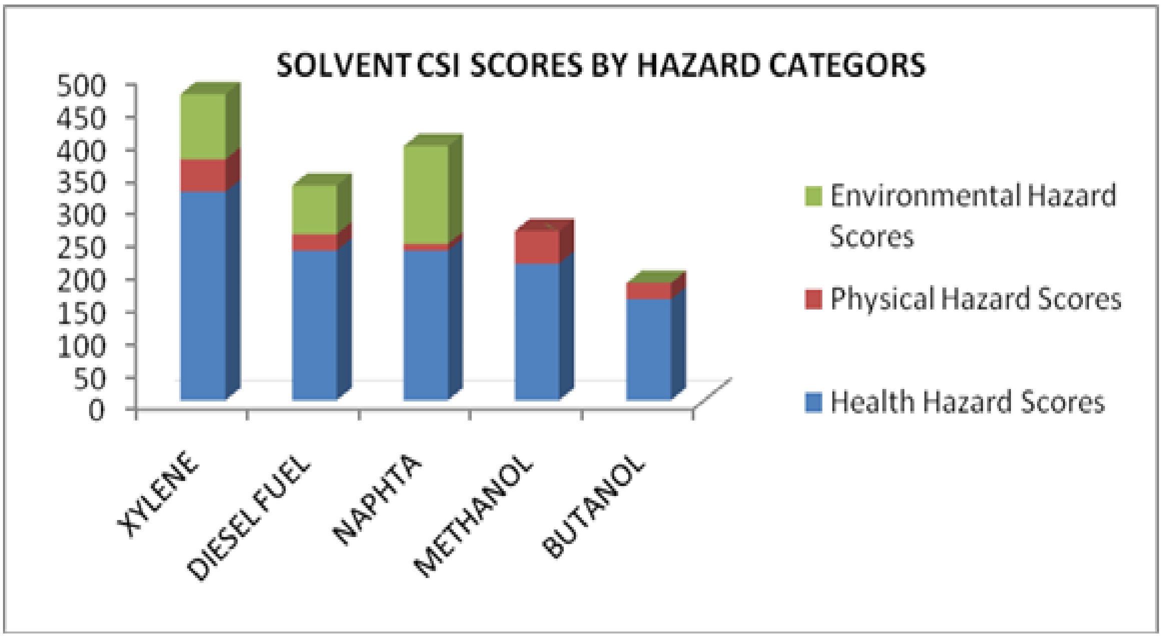


Fig 6:- Hazard Categories' Contribution to Total CSI Scores

ISSN No:-2456-2165

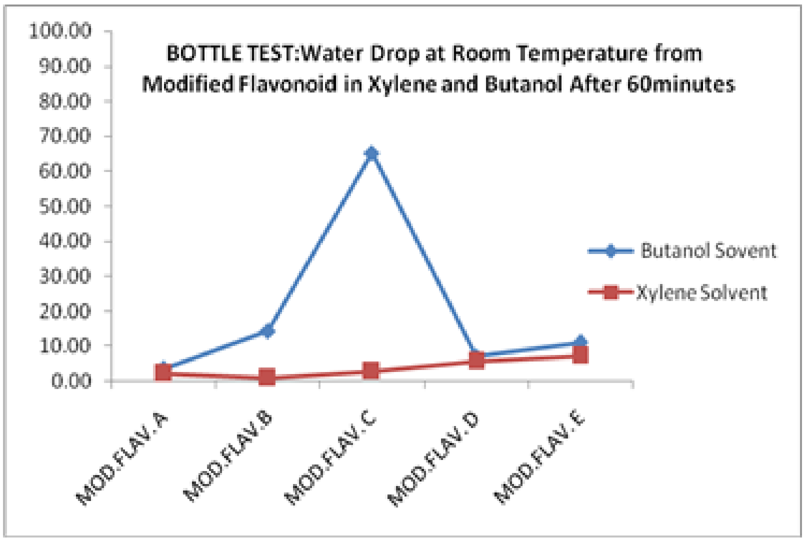


Fig 7:- Comparison of Demulsifiers Efficiency at Room Temperature

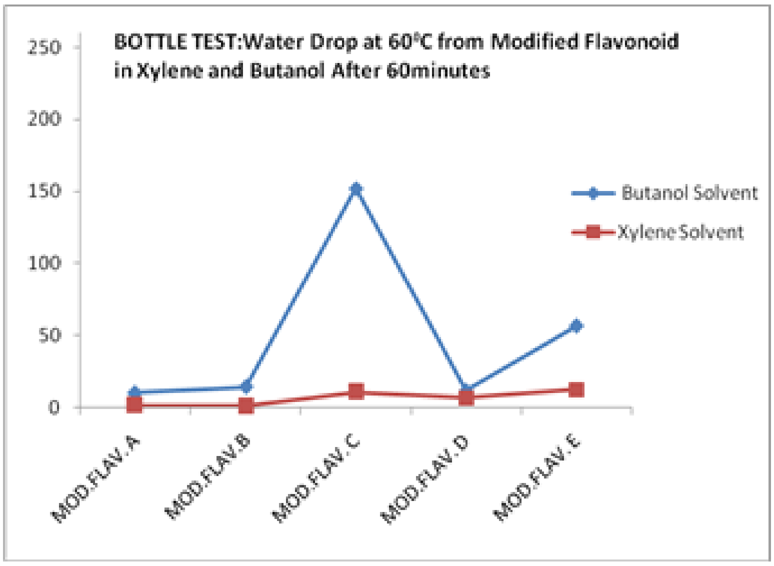


Fig 8:- Comparison of Demulsifiers Efficiency at 600C

PRODUCT	DEMULSIFIER A											
COMPONENTS	XXX		XXX		XXX		XXX		XYLENE			TOTAL
CAS NO.	6151-25-3		98-01-1		16611-84-0		141-43-5		XYLEN	ETHYLBENZENE		
CONCENTRATION%	1%		0.09%		1.40%		0.2%		1330-2	100-41-4		
									> 90 -<	> 25 - < 30%		
ENVIRONMENTAL HAZARD											CSI	
ACUTE /CHRONIC AQUATIC TOXICITY	NO DATA	50	24MG/L	0	CAT 4	1	CAT.3	0	CAT3		50	**101**
BIODEGRADATION-	Readiliy degradable(1324 mg/mg Oxygen demand	0	BOD 46	0	NO DAT	50			NO DATA		50	**100**
		50		0		1		0			100	**201**
HEALTH HAZARD												
CARCINOGENICITY	NO DATA	50	CAT.2	10	NOT CL	0	0	0	CAT3	CAT	100	**160**
ACUTE ORAL TOXICITY	CAT3	5	CAT.2	10	NO DAT	50	CAT.4	0	CAT4	CAT4	10	**165**
ACUTE INHALATION TOXICITY	CAT4	1	CAT.3	1	NO DAT	50	CAT.4	0	CAT4	CAT4	10	**62**
ACUTE DERMAL TOXICITY	CAT4	1	CAT.4	0	NO DAT	50	CAT.4	0	CAT2	CAT2	75	**61**
ACUTE EYE TOXICITY	CAT4	1	CAT.2	10	Categor	25	CAT.1	25	CAT.2	CAT.	75	**136**
CORROSIVITY	CAT4	1	CAT.2	0	NO DAT	50	CAT.1B	1	CAT.2	CAT.	50	**127**
		5		31		225		26			320	**711**
PHYSICAL HAZARD												
FLAMMABLE LIQUID	NO DATA	10	NO DAT	5	NO DAT	10	CAT.4	0	CAT.3	CAT2	50	75
	0	**10**		5		10		0		0	50	**75**
		65		36		236		26			470	**987**

PRODUCT	DEMULSIFIER B										
COMPONENTS	XXXX		XXXX		XXXX		XXXX		N-BUTANOL		TOTAL
CAS NO.	XXX		98-01-1		16611-84-0		141-43-5		71-36-3		
CONCENTRATION%	1%		0.09%		1.40%		0.2%		95-97%		
ENVIRONMENTAL HAZARD											
ACUTE /CHRONIC AQUATIC TOXICITY	NO DAT	50	24MG/L	0	CAT 4	1	CAT.3	0	1840mg/l	0	**51**
BIODEGRADATION-	Readily degradable(1324mg/mg	0	BOD 46	0	NO DAT	50			92% Readily degradable	0	**50**
		50		0		1		0		0	**101**
HEALTH HAZARD											
CARCINOGENICITY	NO DAT	50	CAT.2	10	NOT CL	0	0		no prese	0	**60**
ACUTE ORAL TOXICITY	CAT3	5	CAT.2	10	NO DAT	50	CAT.4	0	CAT.4	10	**75**
ACUTE INHALATION TOXICITY	CAT4	1	CAT.3	1	NO DAT	50	CAT.4	0	CAT.4	10	**62**
ACUTE DERMAL TOXICITY	CAT4	1	CAT.4	0	NO DAT	50	CAT.4	0	CAT.4	10	**61**
ACUTE EYE TOXICITY	CAT4	1	CAT.2	10	Category 2A	25	CAT.1	25	CAT.2	75	**136**
CORROSIVITY	CAT4	1	CAT.2	0	NO DAT	50	CAT.1B	1	CAT.2	50	**102**
		5		31		225		26		155	**496**
PHYSICAL HAZARD											
FLAMMABLE LIQUID	NO DAT	10	NO DAT	5	NO DAT	10	CAT.4	0	CAT.3	25	50
		10		5		10		0		25	**50**
		65		36		236		26		180	**647**

Table 4.0:- Cumulative Effects of Solvent in a Demulsifier

IV. CONCLUSION

In conclusion, it was verified that the Chemical Scoring Index is a valid and reliable method of quantifying HSE hazards inherent in any chemical product and selecting greener solvents. It was observed that solvents with alcoholic functional groups were greener-having lesser HSE impacts than the hydrocarbons and the hydrocarbons in turn were of lesser HSE risks that the groups with benzene rinks.

Quantification of HSE hazards in solvents will promote selection of HSE performing solvents and replacement of components with high HSE risks during chemical formulations.

It is worth noting that the best HSE CSI scores might not necessarily be the selected candidate for the operations, selection must always go with effective performance, cost and HSE .

It is important to conclude that, rather than base chemical acceptance on output performance only, the health, safety and environmental impacts of these chemicals should be reviewed.

The major limitation on HSE hazards quantification using the CSI model is incomplete data in most Safety Data Sheets. It is recommended that regulatory bodies should ensure standard and complete safety analysis of produced chemicals.

ACKNOWLEDGEMENTS

The authors sincerely acknowledge the support of Production Chemistry leadership and staff in actualizing this research work.

REFERENCES

[1]. Abedini,R and Mosayebi, A(2013): Using Demulsifiers for Phase Breaking of Water/Oil Emulsions; Petroleum and Coal 55(1) 26-30.

[2]. Agarwal AK. (2007): Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Progress in Energy and Combustion Science.Vol.33: p233–271. doi:10.1016/j.pecs.2006.08.003

[3]. Jiri Patocka and, Kamil Kuca(2012): TOXIC ALCOHOLS: ALIPHATIC SATURATED ALCOHOLS. Mil. Med. Sci. Lett. (Voj. Zdrav. Listy) 2012, vol. 81(4), p. 142-163 ISSN 0372-7025

[4]. Jordan, A., Daulton, D., and Cobb, J. (2010): Quantitative Ranking Measures Oil Field Chemicals Environmental impact; Paper SPE 135517, presented at SPE Annual Technical Conference and Exhibition held in Italy. September 19-22.

[5]. Sanders, J; Tuck, D. and Sherman, R.(2010): Are Your Chemical Products Green?-A chemical Hazard Scoring System; Paper SPE 126451 presented at SPE international Conference on Health, Safety and Environment, held in Brazil, April 12-14.

[6]. Surisetty V.R, Dalai AK and Kozinski J. (2011): Alcohols as alternative fuels: An overview. Applied Catalysis A: General.; 404: 1–11. doi:10.1016/j.apcata.2011.07.021

[7]. United Nations (UN) (2011): Globally Harmonized System of Classification and Labeling of Chemicals (GHS), 4th Revised ed.; ST/SG/AC.10/30/Rev.5; United Nations: New York City, USA and Geneva

[8]. Verslycke, T, Reid, K, Bowers, T., Thakali, S, Lewis, A, Sanders, J and Tuck, D. (2014): The Chemistry Scoring Index (CSI): A Hazard-Based Scoring and Ranking Tool for Chemicals and Products Used in the Oil and Gas Industry; Sustainability Vol. 6, P.3993-4009; doi:10.3390/su6073993