Ionic Liquids as a Basis Context for Developing High school Chemistry Teaching Materials

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Abstract. This research aims to produce a map of connectedness highschool chemical content with the context of the modern chemical materials applications based on ionic liquids.The research method is content analysis of journal articles related to the ionic liquid materials and the textbooks of high school chemistry and textbooks of general chemistry at the university. The instrument used is the development format of basic text that connect and combine content and context.The results showed the connectedness between: (1) the context lubricants ionic liquid with the content of ionic bonding, covalent bonding, metal bonding, interaction between the particles of matter, the elements of main group, the elements of transition group, and the classification of macromolecules; (2) the context of fuel cell electrolite with the content of ionic bonding, covalent bonding, metal bonding, interaction between the particles of matter, Volta cell, and electrolysis cell; (3) the contect of nanocellulose with the content of ionic bonding, covalent bonding, metal bonding, interaction between the particles of matter, colloid, carbon compound, and the classification of macromolecules; and (4) the context of artificial muscle system with the content of ionic bond, covalent bond, metal bonding, interaction between the particles of matter, hydrocarbons, electrolytes and non-electrolytes, and the classification of macromolecules.Based on the result of this content analysis, the context of ionic liquid is predicted can be utilized for the enrichment of high school chemistry and has the potential to become teaching material's context of high school chemistry in the future.

1. Introduction

Scientific literacy accession is a sustainable and continuously process that growing throughout human life. Student science literacy assessment includes aspects of attitudes, values, basic skills, knowledge and understanding of science. Science literacy assessment for learning in school is only able to measure the seeds of literacy that exist within the students and not to measure the outcome of scientific literacy to be achieved by a person [1].

Chemical literacy as part of the unity of science literacy potentially to be developed at the high school level. According Cigdemoglu and Geban (2015, p.304) Chemical literacy is the students ability to use and connecting the information provided in the chemical problems and the ability of students to use their knowledge and chemistry skills to shows comprehensive information related to daily problems. Many life problems have a close relation within technology, so that the context of the related technology will affect the ability of students in literacy chemistry.

The definition of chemical literacy developed by obtaining an agreement among chemists, educators, and teachers in high school. As a result, the definition of chemical literacy was specified as it looked in Figure 1 (Cigdemoglu and Geban. 2015,p. 302).

1. Chemical content knowledge
   A chemically literate person understands the following:
   A. General chemical ideas
   - As an experimental discipline, chemists carry out scientific investigations, generalize findings, and propose theories to explain to the world.
   - Serves knowledge to other fields in order to explain phenomena

   B. Characteristics (key ideas) of chemistry
   - Explain the macroscopic level by means of the molecular structure of matter
   - Seek the dynamics of processes and reactions
   - Investigate the energy changes accompanied in a reaction
   - Understand/explain life by chemical processes and structures of living systems
   - Appreciate the contribution of scientific language to this discipline
2. Chemistry in context
   Chemically literate students are able to:
   - Understand the knowledge of chemistry in explaining everyday situations
   - Understanding of daily life chemistry, such as being user of new products/technology, a decision process, and involving in social argumentation on chemistry-related issues.
   - See the relatedness of innovations in chemistry and sociology.
3. Higher-order learning skills
   Students who are chemically literate ask questions, investigate relevant information when required. Additionally, he/she can evaluate pros/cons of debates.
4. Affective aspects
   Students who are literate have a fair and rationale perspective of chemistry and its applications. Furthermore, literate students show interest in issues of chemistry, specifically in a non-formal environment like mass media.

Figure 1. Definition of chemical literacy.

De Jong (2006) argues that the context is a situation or event that helps students to be able to acquire concepts, principles, laws and so on. Technological developments being one reference that can be used in selecting the context in order to broaden students knowledge through discussions of issues emerging technologies in the global world.

Modern technology ionic liquid material-based is a learning context that's globally and very interesting to be a topic in the chemistry learning with reasons: First, the attention of the international community of science and technology in the use of ionic liquids as a new generation of green solvent, electrolyte material and fluid engineering in early 21st century was greater, in line with the increasingly strong demands of the industry for the provision of new materials that are reliable, safe, and environmentally friendly for various purposes [2],[3]. In the electrochemistry, ionic liquids research directed as electrolyte materials in batteries, metal plating and sensor systems [4],[5],[6]. Ionic liquids are also directed as green solvents in chemical synthesis, catalysis and bio-catalytic [7],[8],[9]. In the engineering field, the ionic liquid is also used as a heat carrier fluid, lubricants, surfactants and the liquid crystals [10],[11],[12],[13],[14],[15]. Secondly, scientific explanation related to ionic liquid context contains a lot of facts, concepts, principles, laws, models, and theories that can be used to reinforcing high school chemistry content as a medium for developing thinking skills (process/competence) demanded by PISA (Programme for International Student Assessment).

Ionic liquids is a salt that in liquid phase at room temperature or below room temperature and melts overall shape composed of ions consisting of organic cations and inorganic anions [16]. Ionic liquid is a material that only consist of ionic species (cations and anions), doesn't contain neutral molecules, and relatively has low melting point between <100-150^{o}C, although generally at room temperature [17]. In contrast to the molten salt, which usually has a higher melting point and viscosity, it is also highly corrosive. ionic liquids generally in liquid phase at room temperature, has a relatively lower viscosity and doesn't corrosive [18]. Ionic liquids have a very wide range of liquid phase; non-volatile; unburned (non-flammable); have a good thermal stability (in some cases have thermal stability up to 400°C); vapor pressure value can be ignored; able to dissolve many organic and inorganic compounds; and has a diverse miscibility properties by mixed with water or organic solvents [19].

Cation system in the ionic liquid (and liquid crystal ionic) generally an bulk organic cations, such as N-alkylammonium, P-alkylphosfonium, N-alkyl-pyridinium, S-alkylsulfonium, N-alkylpirolidinium, N,N-dialkylpirazolium and N,N-dialkylimidazolium. The biggest fraction of the research focused to the cation N,N-dialkilimidazolium 1, because of the enormous differences in physicochemical properties that can be provided [7].

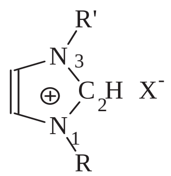

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Figure 2. N,N-dialkylimidazolium 1 cation structure.

The properties of ionic liquids can be adjusted by changing the structure of the cation and anion. The properties of ionic liquids such as thermal properties, electrochemical stability, ionic conductivity and viscosity can be adjusted depending on the cation and anion are arranged to make the ionic liquid known as tailored-made solvents [20]. The melting point of salt ionic liquid 1-alkyl-3-methyl-imidazolium (with R = CH_3) for example, will decline with increasing length of the alkyl group R. After the minimum price achieved (usually in groups hexyl, heptyl, or octyl) melting point will begin to increase with increasing length of the R group [15].

Stability properties of ionic liquids at high temperatures, causing the ionic liquid can be used as a lubricant in the high temperature or low pressure process [11]. Lubricant can prevent or reduce wear and tear as a result of direct contact between two metal surfaces rub against each other so that the wear can be reduced. amount of power needed due to friction can be reduced and the heat generated by friction would be reduced (Lumas Multi Sarana, 2009).

Another utilization of the ionic liquids properties is Fuel Cell. Fuel cell is a power plant that converts chemical energy directly into electricity using hydrogen as fuel and oxygen as oxidant. Fuel Cell acts like a battery that is producing an electrical voltage. The output voltage is generated by the fuel cell is the direct voltage, ranging from 0,7V.

Excellence properties of ionic liquids can be used also to modify the cellulose in some applications nanocellulose. Nanocellulose is cellulose which has a diameter range between 1 to 100 nanometers and have a length about tens to hundreds nanometers, have a relatively high aspect ratio and has high properties of the crystalline structure [21].

Other applications that take advantage of the ionic liquids properties is Electron Active Polymer (EAP) as artificial muscle. In the manufacture of artificial muscles typically used for an actuator material which has properties such as artificial muscles. Actuator is a substance / material that can move when given a stimulus and movements resemble artificial muscles. Materials for the artificial muscle actuator typically uses a polymer known as EAP (Electro Activ Polymers) (Chen, et. al., 2015, p.106).

Based on the ionic liquids contexts review, the purpose of this research was to produce enrichment chemistry books for high school chemistry that can develop students literacy skills. These books will be constructed in order to enrich and improve the mastery of science and technology, skills, and shaping student's personality and other community, which serves as a passage for students and other parties related to the education field (Book Centre of Ministry Education, 2008).

The specific problem in this research is: How does the prospective of use of ionic liquids context in construction high school enrichment chemistry books? To answer these problem descriptive method used through analysis content steps from journal articles that related to the ionic liquids context, high school chemistry books , general chemistry textbooks and high school chemistry content standards curriculum in 2013.

2. Method

This research is an initial step of educational products development, such as determination (define) step, which is done by analyzing the related content of ionic liquids context in journals articles, analyze the chemicals content in high school chemistry books and general chemistry textbooks, as well as the content standard of high school chemistry subject based on curriculum 2013. the research instrument that used is the connectedness format of ionic liquids context and high school chemistry content.

The results of this analysis step will be used to define the design steps. The development step aim to formulating the basic text that the content and context already integrated and inseparable then evaluated the accuracy of its formulation. The process will be guidelines for constructing high school chemistry enrichment book that validated and legibility tested.

3. Result

The results in this research are presented in four types of applications related to ionic liquids context that derived from related journals articles, which includes Application at magnetic lubricating, electrolyte fuel cell, nanocellulose and artificial muscles. In all four application are discussing findings context from journals and it related content.

3.1. Magnetic media lubricant

3.1.1. Contexts analysis result. Findings from the journal articles, generates related terms that must be understood, namely: tribology, friction, wear, andlubrication. Tribology is the study of friction or interacting surfaces in relative motion. Frictionis the resistance to relative motion between two bodies in contact. The magnitude of friction force influenced by weight of the object and the surface roughness touching. Wearis removal (or displacement) of material from one body when subjected to contact and relative motion with another body. Lubricationis the act placing a lubricant between surface muatually shifted to reduce wear and friction [22].

Further explained that is necessary to lubricant used for magnetic media, the media that is normally used to record all data (audiovisual information). In magnetic recording, thin film media typically have their surfaces lubricated to reduce friction and wear resulting from contacts between the read/write magnetic head and media surface. In practice, to avoid adhesion related problems, lubrication has to be achieved with a molecularly thin lubricant film (Homola in Kondo) [23]. It is important that the lubricant remain on the media surface over the life of the file without being subject to desorption, spin off, or chemical degradation [23].

The characteristics which must be met for lubricant for magnetic thin film media with low friction and wear can be summarized as follows high viscosity, low vapor pressure (volatility), low surface tension (replenish surface with lubricant), some affinity to the surface (with polar end group), good thermal and oxidative stability to prevent degradation during storage and use, chemical inertness to metals, glasses and plastics and non-deposit forming to insure no damage to heads, guides, devices, etc., no toxicity and flammability (to prevent degradation in the presence of water), good boundary lubricant (forms easily sheared chemical film during asperity contact), and solubility in organic solvents [23].

The material chemical predicted meets the characteristics is the material based on ionic liquids, because the ionic liquid is a salt compound composed of ions (cation and anion), does not contain any neutral molecules specific, and has a melting poin is relatively low (<100^oC). The cation system in ionic liquid is generally an organic cation with bulk properties. Moreover, the characteristics of ionic liquid can adjusted by changing the structure of the cation and anion [17].

Based on the novel research from Hayashi and Hamaguchi (2004) have found an ionic liquid that has magnetic properties and has the characteristics required as lubricant for magnetic media such as high thermal stability, non-volatile (low vapor pressure), high viscosity, and others [24]. This ionic liquid named [bmim] $FeCl_4$ synthesized from a mixture of compound 1-butyl-3-methylimidazolium dan $FeCl_3$. [bmim] $FeCl_4$ able to respond with strong magnetic field and the results of magnetic susceptibility testing indicate that [bmim] $FeCl_4$ has paramagnetic properties with magnetic susceptibility 40,6 x 10^{-6}emu/g [24]. The magnetic susceptibility is one of measurement method that is non-destructive and effectively used in knowing the existence of paramagnetic elements in the sample. The entire core, individual or sediment sample was placed in magnetic field that causes the sample magnetized and it is highly dependent on the amount of the magnetic substance contained in the sample. Susceptibility Meter type Bartington MS2 is an instrument for measuring magnetic susceptibility. This instrument detects the spin of unpaired electrons that are in the compound. Instruments MS2 or MS3 system can operate by generating a frequency and intensity of the magnetic field generated AC current carrying wire coiled around the sensor.

When a sample is placed near the sensor, the change in the magnetic field intensity generated can be detected by the system and converted into magnetic susceptibility readings for both values either positive is ferromagnetic and paramagnetic and negative is diamagnetic, with a resolution of 2 x 10^{-6} SI units. Measurements conducted are non-destructive or maintain the magnetic characteristics of the sample, and the relative does not affect the conductivity of the sample. Therefore, the magnetic susceptibility of the ionic liquid compound is a small positive and then classified into the metal that is paramagnetic [25]. With this findings are limited to the compound having paramagnetic properties, it is expected to be ferromagnetic compound can be synthesized in the future because of the strength of magnetic properties can make better quality lubricants in overcoming problems of friction and wear.

3.1.2. Content analysis result. The results of content analysis of high school chemistry and general chemistry textbooks mentions that the cation is a positively charged particle, which is formed from metal atoms lose valence electrons that are positively charged. By discussing the ionic liquid material, theses is widespread understanding of the cation is not only derived from the metal atom but also as positively charged organic molecules. Between the cation and anion occurred electrostatic attraction, forming an ionic bonding.

Other analysis of chemical content is the viscosity. Viscosity caused by the cohesive forces between like molecules. The cohesive force decreases as the temperature increases, because the force between molecules are declining. If a liquid has a strong intermolecular forces, the viscosity will be higher than the liquid has a weak intermolecular forces. Intermolecular forces are attractive force between molecules that include Van Der Waals forces, dipole-ion forces, and hydrogen bonding. The cohesion forces (the intermolecular attraction between like molecules) and adhesion forces (the intermolecular attraction between like molecules) causes the surface tension**.** Another phenomenon that arises when the phase change from liquid phase to gas (steam) phase or otherwise involves an equilibrium which is called vapor pressure**.** If a substance that has a low vapor pressure, the high boiling point. Boiling point is strongly influenced by intermolecular forces. The stronger the intermolecular forces then its boiling point will be higher and its means a low vapor pressure (non-volatile) [26].

The chemical content analysis of chemical elements subject matter give information that the aluminium alloys with magnesium or often called alnico can form a strong magnet. Metal that is highly resistant to corrosion are chromium (Cr), so that the chromium metal is often used as an alloy. Alloy formed from a mixture of cobalt (Co), chromium (Cr), and tungsten (W) the nature of which remains hard despite heated to very high temperatures. In addition, the alloy is formed from metal Co and Cr have ferromagnetic properties that can be applied to the magnetic coating on the magnetic recording medium. The phenomenon of ferromagnetic properties is only applicable if the materials in solid form. Not all of the elements that contain an unpaired electron in solid form having ferromagnetic properties. To form the ferromagnetic properties can be done by setting the exact distance between the paramagnetic ions, the ions so that each can held on to form a magnetic field. Metal that has no ferromagnetic properties (non-ferromagnetic), which lies between the ions are very close together, can be made is by being converted into a ferromagnetic alloy. This has been accomplished on chromium, where the addition of a cobalt cause Cr^{2+} ions in a geometric pattern of very strong interaction to form a magnetic field, so that the ferromagnetic alloy [27].

Another content chemical analysis of lubricant is polymer. Polymers are very large molecules (often called macromolecules) formed from the merger of small molecules called monomers, which is a recurring unit. Polymers can be chemically degraded to break down into simpler molecules, both natural and artificial [26]

3.2. Electrolyte fuel cell

3.2.1. Contexts analysis result. Findings from the journal articles provide information about the terms of the fuel cell. Fuel cells are electrochemical devices that convert chemical energy in fuels into electrical energy directly, promising power generation with high efficiency and low environmental impact [28]. Typically, a process of electricity generation from fuels involves several energy conversion steps, namely [29]:

- Combustion of fuel converts chemical energy of fuel into heat,
- This heat is then used to boil water and generate steam,
- Steam is used to run a turbine in a process that converts thermal energy into mechanical energy, and finally
- Mechanical energy is used to run a generator that generates electricity.

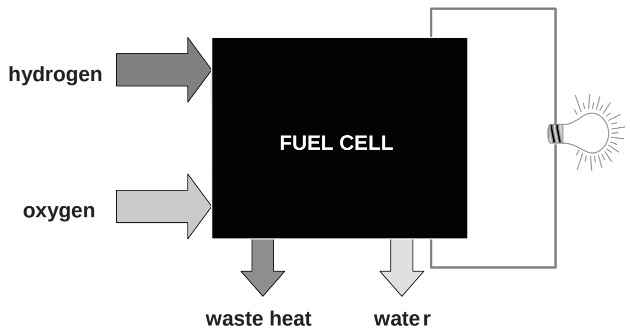

Figure 3. Fuel cell scheme.

A fuel cell in some aspects is similar to a battery, but it requires a constant supply of fuel and oxidant, and it electrode do not undergo chemical changes.

Fuel Cell could be work continuing as long as it fuel and oxidant are available. Typical reactants for fuel cells are hydrogen and oxygen; however, neither has to be in its pure form. Hydrogen may be present either in a mixture with other gases (such as CO_2, N_2, CO), or in hydrocarbons such as natural gas, CH_4, or even in liquid hydrocarbons such as methanol, CH_3OH. Ambient air contains enough oxygen to be used in fuel cells. Yet another difference between a fuel cell and a battery is that a fuel cell generates by-products: waste heat and water, and the system is required to manage those (a battery also generates some heat but at a much lower rate that usually does not require any special or additional equipment) [29].

Fuel cell contains two electrode, wich is anode and cathode that separated by electrolyte. Hydrogen supplied to the fuel cell through the anode, however Oxygen or ambient air supplied to the fuel cell through the cathode [28]. By the electrolyte hydrogen and oxygen couldn’t be mixed. Electrolyte functioned as catalyzator that can decompose hydrogen to electron and proton. Protons flow through the electrolyte, while the electrons can not pass through the electrolyte, so that electrons would pile up at the anode, while in the cathode positively charged ions piled up. When the anode and the cathode is connected to an electrical conductor, there will be a flow of electrons from the anode to the cathode, so that there is an electricity. The chemical reactions that occurs in the fuel cell :

$$Anode : 2H_2 \rightarrow 4H^+ + 4e^-$$
$$Cathode : O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

The use of hydrogen that contained in the fuel cell can be designed as a portable system that can be moved and has a light mass. Unlike the combustion system found on conventional transport equipment (use the piston in a car/motorcycle), the Fuel Cell has no moving parts or vibrating so will not causing pollution. Fuel Cell can be applied in various types of applications that use energy as in cell phones, personal computers, power station as in hospitals, office buildings, schools and also on vehicles such as motorcycles and cars.

3.2.2. Content analysis result. The results of high school chemistry content and general chemistry textbooks analysis explain that the electrochemical interpreted as a chemical changes that produce an electricity or chemical changes that produce an electricity [30]. Electrolytes are substances that can dissociate into ions, can be solids dissolved in a suitable medium or in molten form an ionic compound that can conduct electricity. Electrical energy is generated due to the movement of electrons in a solution or ionic liquids. Electrons move from the negatively charged electrode (anode) to the positively charged electrode (cathode) [26].

Another content analysis result explained that Volta cells or galvanic cells are electrochemical cells that can undergo oxidation-reduction reactions spontaneously to generate electricity [30]. In the Volta cell, two parts of the redox reaction are separated, it is done so in such there is a transfer of electrons in the system . In this way, useful electrical energy obtained. In some electrochemical cells spontaneous chemical reactions can occur with electrical energy drain, this process is called electrolysis [26]. Electrolysis cell consists of a container for reaction with the electrode material is immersed in an electrolyte and connected to a source of direct current. Inert electrodes are often used so that they do not react.

3.3. NanoCellulose

3.3.1. Contexts analysis result. The results of the study on several journal articles generate information that nanocellulose is cellulose molecule, being in nanometer size and has large surface area (150 m^2/g) (Bai *et al* in Tan *et al*) [21] . Nanocellulose divided into two kinds, namely cellulose nanofibrils (CNF) or better known as nanofibrillar cellulose (NFC) and cellulose nanocrystals (CNC) or better known as nanocrystalline cellulose (NCC) [31], [32]. Nanoselulosa can be obtained from plant cell walls (Klemm *et al* in Chirayil *et al*) [33] CNF can be obtained by mechanical method (Moon *et al* in Salas *et al*) [31], while CNC can be obtained by three main stages: pre-treatment of cellulose in which the most common method is acid hydrolysis to break down the amorphous part of cellulose, addition of anti-solvent to regenerate the cellulose and followed by treatment of sonication to disperse the CNC uniformly (Sheltami *et al* 2012; Man *et al* 2011; Lu *et al* 2013; in Tan *et al*) [21]. Moreover, nanocellulose can be obtained by dissolving cellulose in ionic liquids (Swatloski *et al* in Isik *et al*) [34]. Ionic liquids from the result of a merger between the cation 1-butyl-3-methylimidazolium and various types of anions have been investigated as a solvent of cellulose (Swatloski *et al* 2002; Gericke *et al* 2012 in Isik *et al*) [34].

The results of further studies on the context, it was found that nanocellulose very easy to form hydrogels (Hoffman, 2002; Jen *et al*1996; in Salas *et al*) [31]. Compared to CNC, CNF forms hydrogels more readily (Klouda and Mikos, 2008; Lee and Mooney, 2001; in Salas *et al*) [31]. Nanocellulose can also form a suspension in a non-polar dispersing medium by adding a surfactant to the system [35]. Nanocellulose can also form an emulsion systems, nano-cellulose is used as a stabilizer in the emulsion system [31], because nanocellulose containing hydrophilic group on its surface [35]. Hydrophilicity of nanocellulose can form an oil-in-water (O / W) emulsion (Oza and Frank in Salas *et al*) [31]. However, nanocellulose can also form a water-in-oil (W / O) emulsion by modifying the surface of nanocellulose (Lif *et al* 2010; Xhanari *et al* 2011; in Salas *et al*) [31]. In addition, nanocellulose can also form a stable foam. CNF and CNC can form a stable foam by modifying the surface of nanocellulose into a hydrophobic surface (Cervin *et al* in Salas *et al*) [31].

It was also found in several journal articles that nanocellulose applications in daily life is very broad. For example in the field of industrial electronic and optic devices (Bai *et al* 2009; Lu *et al* 2013; in Tan *et al*) [21], regenerative medicine (Lu *et al* 2013; Lu and Hseih 2010; in Tan *et al*) [21], a thickener in cosmetics, stabilizers in the food industry, enhancing the quality of the paper and furniture, as well as composite materials for construction (buildings) and vehicles (Mandal and Chakrabarty, 2011; Bai *et al* 2009; Haafiz *et al* 2013; Voronova *et al* 2012; in Tan *et al*) [21]. Nanoselulosa can also be used as coating materials, optical devices, stabilizers in the multiphase systems, and as a reinforcing material in the nanocomposite [31].

3.3.2. Content analysis result. The results of the study on several chemistry books for high school and chemistry books for universities produce information that the chemical content related to the context of nanocellulose is polymer content. Polymers are large molecules that formed from the simple repeating units. The term of polymer is derived from the Greek, *Poly* means "many", and *mer* meaning "section" [36]. Based on the many kinds of monomers making up the polymer, the polymer is divided into two. If a polymer was prepared only from a single monomer, then the polymer is classified as a homopolymer, whereas if a polymer prepared by more than one type of monomer then the polymer is classified as copolymer [36].

Another chemical content related to the context of nanocellulose is carbohydrate content. Carbohydrates are polyhydroxy aldehydes or ketones, or substances that yield such compounds on hydrolysis. Many, but not all, carbohydrates have the empirical formula $(CH_2O)n$, some also contain nitrogen, phosphorus, or sulfur. There are three major size classes of carbohydrates: monosaccharides, oligosaccharides, and polysaccharides (the word “saccharide” is derived from the Greek, meaning “sugar”). Monosaccharides, or simple sugars, consist of a single polyhydroxy aldehyde or ketone unit. Some of the monosaccharide units can form oligosaccharides, which are connected by bonds called glycosidic bond. In addition, a combined 20 or more monosaccharide units can form a polysaccharide. Some polysaccharides, such as cellulose, are linear chains; others, such as glycogen, are branched. Both glycogen and cellulose consist of recurring units of D-glucose, but they differ in the type of glycosidic linkage and consequently have strikingly different properties and biological roles [37].

Another chemical content related to the context of nanocellulose is about colloidal or colloidal dispersion. Colloidal dispersion is a collection of particles measuring between 1-1000 nm (the dispersed phase) is dispersed in the dispersing medium. The size of the colloidal particles is greater than the atomic and molecular size, so that the colloidal particles have physical and chemical properties that are different from atoms and molecules and also have different properties with macromolecules [38]. Colloidal dispersion is divided into eight types, which are summarized in the following table:

Table 1. Classification of colloidal dispersion [38].

Dispersed phase	Dispersion Medium	Name
Gas	Liquid	Foam
Gas	Solid	Solid Foam
Liquid	Gas	Liquid Aerosol
Liquid	Liquid	Emulsion
Liquid	Solid	Solid Emulsion
Solid	Gas	Solid Aerosol
Solid	Liquid	Sol, Suspension
Solid	Solid	Solid Suspension

Another chemical content related to the context of nanocellulose is the content of hydrogen bonds. The hydrogen bond is a special type of intermolecular forces between the dipoles hydrogen atom in a polar bond such as N-H, O-H, and F-H, with the atom electronegative O, N, and F [26]. Hydrogen bonds can be interpreted also as the bond between the H atoms in polar molecules and atoms with high electronegativity on polar molecules. Hydrogen bonding can occur in the polar molecule (called the intramolecular hydrogen bond), or it can also occur intermolecular polar (called intermolecular hydrogen bonding) [39].

3.4. Artificial muscle

3.4.1. Contexts analysis result. The results of the context research in several journal articles generate artificial muscle definition. Artificial muscle is a kind of actuator generally defined by analogy with the skeletal muscle. Like the natural muscle, any artificial muscle is characterized by its ability to contract in response to a chemical or physical stimulus [40]. Artificial muscles can be formed of a polymersmaterial that change shape or size in response to electrical stimulus are called electroactive polymers (EAP)

[41].The most attractive feature of EAPs is their ability to emulate biological musclesoffering resilience, toughness, large actuation strain, inherent vibration damping and soft with a quick response when stimulated electric field [42].

Further studies the in context from journal articles explaining thatpolymer artificial muscles have been divided into two major groups. In the first group, dimensional change (actuation) is in response to an electric field. These are commonly known as electronic or electric electroactive polymers (EAPs) [43]. Some of the technologies that fall under this category are :

Table 2. List of the leading electronic EAP materials [42].

Electronic EAP
• Dielektric elastomer EAP • Elektroactif graft elastomers • Electroactive-viscoelastikc elastomers • Ferroelektric polymer • Liquid Christal Elastomers (LCE)

The second group of polymer artificial muscles is a class of materials in which the presence and movement of ions is necessary to make actuation possible. This group is referred to as ionic EAPs. For the ions to be able to move, an electrolyte phase is necessary, which is often liquid; so these actuators are also known as wet EAPs [43]. Some of the technologies that fall under this category are :

Table 3. List of the leading Ionic EAP materials [42].

Ionic EAP
• Carbon Nanotube (CNT) • Conductive Polymer (CP) • Ionic Polymer Gels (IPG) • Ionic Polymer Metalllic Composite (IPMC)

The electronic polymers be made to hold the induced displacement under activation of a DC voltage, allowing them to be considered for robotic applications. Also, these materials have a greater mechanical energy density and they can be operated in air with no major constraints. However, they require a high activation fields (>100-V/mm) close to the breakdown level. In contrast, ionic EAP materials require drive voltages as low as 1-2 Volts. However, there is a need to maintain their wetness, and except for conductive polymers it is difficult to sustain DC-induced displacements [44].

Also described in several articles that the technologies of artificial muscle polymer are being developed that can produce the same strain and high pressure using electrostatic forces, elektrostriksi, ion insertion, and changes in molecular conformation. Materials used include elastomers, conductive polymers, ionic polymers and carbon nanotubes. Other technologies using elastomer actuator dielectrik (Dielectric Elastromer Actuator), ferroelectric polymer and liquid crystal elastomers. In addition, alternative way another of obtaining actuation in the polymer is to use the movement of ions in the polymer [42].

3.4.2. Content Analysis Result. The result of the study on several chemistry books for high school and chemistry books for universities produce information that the chemical content related to the context of artificial muscle is polymer content. Polymers are large molecules formed from the simple repeating units. The term of polymer is derived from the Greek, Poly means “many” and mer means “section” [36].

Another chemical content related to the context of artificial muscle, that is:

- Stress, is defined as the change in force to the cross-sectional area which is subject to force
- Strain, is defined as the ratio of length change material to the original length due to a force with a direction parallel to the length change [45]
- Conjugation, is defined as a electron bonding cloud system formed by the interaction between the electron cloud on the double bond and a single bond : happen on molecule (generally organic molecules) containing a double bond and a single bond criss-cross. The interaction that occurs the form of clouds of electrons double bond delocalized (shifted) to the single bond.Example of simple compounds that have the conjugation bond is: H2C=CH-CH=CH2 [39].
- Elastomer,is defined as a polymer that has the ability to stretch and return to its original state quickly [36].
- Conductivity Electrical in Polymer, is a polymer that can conduct electricity if the polymer occurs electron delocalization in conjugation bond, have cis-tran isomer and has a heterocyclic ring [36]
- Electrostatic forces, is defined as the force generated by electrically charged objects [39].
- Covalent Bond, defined as the bond formed between atoms that share electrons [46].

4. Conclusion

Based on the context and content analysis, can be concluded that the relevant ionic liquids context such as (1) ionic liquid lubricants, (2) electrolyte fuel cell. (3) nano cellulose, and (4) the artificial muscle potentially to be used as material for enriching chemical bonds content. In addition the context (1), (3) and (4) the potentially to be used as material for enriching macromolecule/polymer content; the context (1) potentially to be used as material for enriching chemical elements content, the context (2) potentially to be used as material for enriching electrochemical content, the context (3) potentially to be used as material for enriching colloids content, and context (4) potentially to be used as material for enriching electrolytes and non electrolytes content.

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