Reaction Kinetics The Formation of Calcium Sulfate From Cow Bone And Sulfuric Acid In Batch

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Abstract. Cow bone is one type of solid waste that has not been utilized. This waste materials, contains a lot of calcium phosphate. When reacted with sulfuric acid it will form calcium sulfate. The research aimed to find the speed constant value of calcium sulfate formation reaction from cow bone powder with batch sulfuric acid. A 200 mesh cow bone powder is dissolved in water to form a saturated solution. This saturated solution was taken as much as 500 ml then reacted with 4 N sulfuric acid as much as 100 ml, stirred with stirring speed of 200 rpm, with temperature and time according to the variable being run. After reaching the studied condition, the filtrate is separated by its sediment. The precipitate was analyzed for the content of calcium sulfate. The variables studied in this study were reaction temperature (65°C, 75°C, 85°C, 95°C, and 105°C) and reaction time (15, 25, 35, 45, 55 and 65 minutes). The results showed that the reaction follows a pseudo first order reaction, obtained by the equation \( k = 3.09 e^{-973.5/T} \).

1. Introduction
The results of slaughter of cow in slaughterhouses will produce the main products in the form of meat, while the bones are part of which has not been utilized optimally. While the bones are cut back a lot of unused ones. Cow contains a lot of calcium phosphate and is the largest composition of the bone. [1] Cow bone can be processed by hydrolysis with hydrochloric acid to produce gelatin [2]. This very high phosphate content in cow bone is processed into phosphoric acid and calcium sulfate by reacting with sulfuric acid in this case once the kinetics of the reaction of phosphoric acid have been carried out from chicken bone raw material [3]. While the reaction kinetics of making phosphoric acid from bone ash with a dry process have been carried out without a dissolution process [4]. The synthesis of phosphoric acid production from cow bone has also been carried out without directly without dissolution [5]. Calcium sulfate can be formed from the nature of the compounds contained in limestone which is composed of calcium [6]. Cow bone ash contains many oxide compounds such as calcium oxide and phosphate which have a relatively open skeletal structure [7]. The cow bone powder is reacted with sulfuric acid, calcium Sulfate will form. Calcium sulfate is generally white [8]. The relation between Ca and P is the value of the provisions in cow bones organisms [9]. The calcium phosphate composition has osteon conductive properties [10]. Calcium sulfate is used to smooth the surface of nickel metal and to reduce the salt content in the soil [11]. In this study, the kinetics of calcium sulfate formation reaction will be studied using solubility in cow bone powder which reacted with sulfuric acid in a batch process. Factors influence is an important role in accelerating or slowing down certain reactions. Concentration affects the rate of the reaction. Temperature. The increase in temperature can accelerate the rate of reaction because with the increase in temperature, the kinetic energy of the particles of the substance increases so that it allows more and more effective collisions to
produce changes. The rate constants and activation energy are connected by the Arrhenius equation. The longer reaction time to get the conversion better because the longer the reactants for mutual contact to produce changes (products obtained). The stirring it will increase the chance of reagent substances to collide with each other, so that the reaction goes well [12]. A comparative study of precipitation has been done with different salts of calcium and determination of optimal conditions of factors affecting the reduction of fluoride [13]. Gypsum is used as generic name for several types of products with a chemical composition of calcium sulfate, gypsum is mainly used in cement industry as a conditioning agent [14]. Calcium sulfate alone cannot be effectively used as a bone filler [15]. Calcium phosphate and the primary inorganic component of natural hard tissues including bone and tooth both in vertebrate animals and human [16], it has the same inorganic composition and fully interconnected porous structure as bone and is fabricated by compositional transformation, based on a dissolution-precipitation reaction using tri calcium phosphate [17]. Synthetic calcium phosphate ceramics are widely used as bone filling materials as a substitute to auto thanks to their similarity with the inorganic phase of bone and their osteo conductive properties [18]. Doped calcium phosphate bio ceramics are promising materials for bone repair surgery because of their chemical resemblance to the mineral constituent of bone [19]. The most used calcium phosphate in implant fabrication, a biological active material with different forms, particles, films, coatings, fibers, bio composites which has extensive biomedical applications [20]. Theories on the formation of transient precursor phases in bio mineralization, the dissolution and re precipitation as bone of calcium phosphate are discussed [21]. Calcium phosphate mediated transfection has been used for delivering DNA into mammalian cells in excess of 30 years due to its most low cost for introducing recombinant DNA into culture cells [22]. Calcium phosphate have been shown to be able to achieve a good outcome in repairing small defects in the clinic [23]. Dissolution of calcium phosphate ceramics degrades its properties affecting formation of the calcium phosphate layer [24]. A biomaterial when degraded must be nontoxic and readily resorbed or excreted Calcium phosphate degrades as like bones [25]. Phosphates exhibit different biological re sorption capacities, so that an adequate balance [26]. Calcium phosphates are complex mineral salts with high geological and biological occurrence. Geologically, they are widely distributed on the surface layer of the Earth [27]. Phosphorus and calcium are essential macro minerals; they are the most abundant mineral nutrient in the body [28]. For successful biomedical application, it is important to prepare nano phase calcium phosphate with proper morphology and narrow size distribution [29]. To employ calcium phosphate compounds in ground improvement measures such as the reinforcement of soil and rock, examined suitable conditions for precipitation [30]. The recent advancements in materials science have prompted a rapid progress in the preparation of calcium phosphate with nano metric dimensions [31]. The bio mineral calcium phosphate phase (one or more types of calcium phosphate) comprises up to 70% of bone constituents, the remainder consisting of water and an organic phase, such as collagen [32].

2. Materials and Method

This research used cow bone powder which contained calcium phosphate which was first dissolved in water. Until a saturated solution is obtained. In this study the size of cow bone powder used was 200 mesh. This saturated solution is then reacted with sulfuric acid which is a homogeneous reaction between the liquid-liquid phases to form calcium sulfate. The reactions that occur in making calcium sulfate are as follows:

\[
\text{Ca}_3(\text{PO}_4)_2(l) + 3 \text{H}_2\text{SO}_4(l) \rightarrow 2 \text{H}_3\text{PO}_4(l) + 3 \text{CaSO}_4(s)
\]

The equation for the rate of reaction is as below:

\[
\frac{dC_A}{dt} = -k C_A C_B^3
\]
Sulfuric acid which is used in research is excessive so that sulfuric acid can be calculated constantly (1) the equation change to:

\[
\frac{dC_A}{dt} = -k' C_A
\]  

(2)

\[
\int_{C_{Ao}}^{C_A} \frac{dC_A}{C_A} = -k' \int_{0}^{t} dt
\]

(3)

\[
\ln C_A - \ln C_{Ao} = -k' t
\]

(4)

The bonds and initiate the reaction, the rate constants and activation energy are connected by the Arrhenius equation.

\[
k = Ae^{-Ea/RT}
\]

(5)

Information:
Ea = Activation Energy
T = Temperature (K)
A = Frequency Factor
\(e\) = Mathematical Quantity
k = Rate Constant

By knowing the solubility of calcium phosphate, it can be seen the amount of bone powder dissolved first to reach the homogeneity of a material.

2.1. Preparation of materials
The mashed cow bone powder is then sifted with a size of 200 Mesh, so the results obtained have a uniform particle size. Cow’s bone powder with a certain weight is dissolved in 500 ml water until it forms a homogeneous solution. Make H\(_2\)SO\(_4\) solution with a concentration of 4 N as much as 100 ml.

2.2. Wet process in batch reactor
Saturated solution from cow bone made by dissolving 100 grams of cow bone in 500 ml, put in three neck flasks, then adding 100 ml H\(_2\)SO\(_4\) solution with a concentration of 4 N, heated while stirring at a speed of 200 rpm until it reaches the temperature studied (65°C, 75°C, 85°C, 95°C, and 105°C) in time according to the variables carried out (15, 25, 35, 45, 55, and 65 minutes). After that the sediment and filtrate are separated. The deposits obtained were dried and weighed and analysis for the content of calcium sulfate. Figure 1. Information 1. Heater Magnetic 2. Three-neck Rounded Flask 3. Thermometer 4. Clamp holder and stat 5. Condenser 6. Stirrer Magnetic

![Figure 1](image1.png)  
**Figure 1** The set of tools for wet process batch

![Figure 2](image2.png)  
**Figure 2** Flow sheet
3. Result and Discussion
The cow bone powder used contains Calcium phosphate as much as 12.88%. Saturated solution made from 100 grams of cow bone powder 200 Mesh in 500 ml of water. The research results obtained are as follows:

**Figure 3** The relation between calcium sulfate conversion and reaction time at various reaction temperatures

From Figure 3 it can be seen that the longer the processing time, the greater the conversion obtained. Because the longer the processing time, the opportunity for contact between reactants is also getting longer, so the calcium obtained is also getting bigger so that the conversion is also getting bigger. The greater the temperature of the reaction of calcium sulfate conversion is also greater. Because with the increase in temperature, the kinetic energy of particles increases so that more and more effective collisions can produce changes. The resulting calcium sulfate is relatively small, and the largest conversion is obtained at a reaction time of 65 minutes and a temperature of 95°C of 0.0462 parts.

**Figure 4** The relation of -ln (1-xA) and reaction time (t) at various reaction temperatures.

Based on equation (4) and figure 4, the slope of each temperature can be known and the slope value is the value of the reaction speed constants for each temperature. With higher temperatures, the price of the reaction rate constants increases. The increase in temperature can accelerate the rate of reaction because with the increase in temperature, the kinetic energy of the particles of the substance increases so that it allows more and more effective collisions to produce changes. Based on frequency factor, a reaction occurs when a molecule collides with considerable energy called activation energy. the rate constants and activation energy are connected by the Arrhenius equation. Based on figure 4, the rate of reaction constant value (k) in temperature range 65 -105°C is 0.001 -0.015 / minutes.
Figure 5 The relation of $\ln k$ and $1/T$

Based on Figure 5, the equation for the rate reaction constant $k = 3.09 e^{-9735.5/T}$

4. Conclusion
The conclusions for this research are as follows:
1. The best of the conversion reaction obtained depend on the bigger of reaction time and temperature.
2. In the temperature range, the constant value follows the equation.
3. Calcium sulfate formation reaction follows the pseudo first order reaction and constant rate of reaction is follows the equation $k = 3.09 e^{-9735.5/T}$
4. The best conversion of this reaction is 0.0462 parts.

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