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PRELIMINARY SYNTHESIS OF CALCIUM CARBONATE USING CO2 BUBBLING METHOD FOR BIOMEDICAL APPLICATION 1-6
N.H. Azzakiroh[1] , Z. Hasratiningsih[2], I.M. Joni[3], A.Cahyanto[2]

COMPARISON OF THE DIAMETRAL TENSILE STRENGTH OF BONE CEMENT BASED ON CARBONATE APATITE BETWEEN MICRON AND NANO PARTICLES CALCIUM CARBONATE AS A PRECURSOR 7-11
L. Arianti[1] , E. Karlina[2], A. Cahyanto[2]

APATITE CEMENT VERSUS CARBONATE APATITE CEMENT 12-16
A. Cahyanto1*, M.N. Zakaria2

BIOCERAMICS MATERIAL: LIFTING HOPE IN ENDODONTICS 26 17-23
M. N. Zakaria1, A. Cahyanto2 26

REVIEW ON BIOCERAMIC NANOFIBER USING ELECTROSPINNING METHOD FOR DENTAL APPLICATION 33 24-31
N. Djustiana*, Y. Faza, A. Cahyanto 33

MICROLEAKAGE IN COMPOSITE RESTORATION DUE TO THE APPLICATION OF CARBAMIDE PEROXIDE BLEACHING MATERIAL WITH A CONCENTRATION OF 10%, 15% AND 20% 42 32-37
Renny Febrida1,a* , Elin Karlina1,b , Oksania Wahyuni Putri2,c 42

RECONSTRUCTION PROCEDURE USING ELASTOMER PUTTY MATERIALS, WHAT TYPE TO CHOOSE? 49 38-44
V. Takarini1, E. Karlina1, R. Febrida1, Z. Hasratiningsih1 49

EFFECT OF BAGGASE FIBER (Saccharum officinarum L) ON FLEXURAL STRENGTH OF COMPOSITE RESIN 56 45-51
IT. Amirah*, M. Hudiyati**, MC. Negara** 56

THE KNOWLEDGE OF BPJS HEALTH AMONG BANDUNG INFORMAL SECTOR WORKERS AS BPJS HEALTH CARD OWNER 52-63
1Agata Ayu Pratiwi, 1Cucu Zubaedah, and 1Sri Susilawati

ORAL HYGIENE INDEX OF QUADRIPLEGIC ATHLETES IN BANDUNG 64-72
Mochamad Nur Ramadhani1, Riana Wardani2 and Cucu Zubaedah2

Preliminary synthesis of calcium carbonate using co_2 bubbling method for biomedical application

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ABSTRACT

INTRODUCTION : Calcium carbonate ($CaCO_3$) is widely used in biomedical application such as biomaterial for bone subtitute, drug delivery system, calcium supplement and others. $CaCO_3$ natural form can be easily found either in a limestone processing. Carbonation or CO_2 bubbling method is required to obtain $CaCO_3$ from bulk limestone.**Objective :**The aim of this study was to synthesize $CaCO_3$ from Palimanan limestone by CO_2 bubbling method.**Materials and methods:** Limestone was calcinated at 900ºC to get calcium oxide (CaO). Then, 84 gr CaO was hydrated in 1.5L water at 50ºC in an hour to get lime slurry ($Ca(OH)_2$). Lime slurry carbonated by bubbling method with temperature 60ºC, constant flow rate of CO_2 at 10L/min and stirred at 300 rpm to obtain CaCO3 particles. Particles of $CaCO_3$ arethen characterized by Energy Dispersive Spectroscopy (EDS), and X-Ray Diffraction (XRD). **Result :** Energy Dispersive Spectroscopy showed elements forming was $CaCO_3$. X-Ray Diffraction pattern of $CaCO_3$ produced trigonal calcite crystalline structure. **Conclusion :** $CaCO_3$ successfully synthesized using CO_2 bubbling method . Hopefullly this $CaCO_3$ particles might be used widely in biomedical application. Further study is awaited based on these initial findings.

Keywords:*Synthesize of $CaCO_3$, CO_2 bubbling, EDS, XRD*

INTRODUCTION

Calcium carbonate ($CaCO_3$) is widely used in biomedical application. Biomaterial for bone subtitute and drug delivery system for osteomyelitis during bone surgery [1,2]. $CaCO_3$ can be used as abrasive material in toothpaste [3]. $CaCO_3$ also can be used as therapy for dentine hypersensitivity from prophylaxis paste. Calcite form of $CaCO_3$ can be used as dentifrices and polishing materials [4]. $CaCO_3$ natural form can be easily found either in a limestone processing[5]. Carbonation or CO_2 bubbling method is required to obtain $CaCO_3$ from bulk limestone [6].

Natural $CaCO_3$ can be found at several forms like mollusc shells and egg shells. This shells fossil can be found in limestone which is almost 90% contain $CaCO_3$. The worldwide availability of $CaCO_3$, compatibility and non-toxicity towards the human body make synthesis of this material an interesting and attractive topic for scientists and researcher to delve into. Therefore, so many research have been undertaken to stabilize specific $CaCO_3$ polymorphs at different size and morphology [5].

Two main $CaCO_3$ synthesis methods there are biomimetic method and CO_2 bubbling method. Biomimetic method attempts to imitate nature's ability to synthesize various shapes and size by using physiological parameters and soluble organics. The current industrial synthesis is CO_2 bubbling method which use CO_2 bubble into slaked lime to get $CaCO_3$ particles [5].

CO_2 bubbling method is very efficient at producing micro or nano sized particles which are the most needed size in industry and research. The morphology that can mainly be achieved are cubic or rombohedral [5].

$CaCO_3$ have three polymorphs, they are calcite which is thermodynamically stable, vaterite, and aragonite [1,7]. An important factor during carbonation process is temperature [8]. Scalenohedral $CaCO_3$ formed at 41-90ºC [9]. Another research showed needle like form aragonite formed at 60ºC [10]. Different shapes can be exhibited by $CaCO_3$ like spheres, cubes, irregular, pyramid, hollows, and many else [5].The aim of this study was to synthesize $CaCO_3$ from Palimanan limestone by CO_2 bubbling method at 60ºC.

METHODS

Limestone was calcinated at 900ºC to get calcium oxide (CaO). Then, 84 gr CaO was hydrated in 1.5L water at 50ºC in an hour to get lime slurry ($Ca(OH)_2$). Lime slurry carbonated by bubbling method with temperature 60ºC, constant flow rate of CO_2 at 10L/min and stirred at 300 rpm until suspension reach neutral pH to obtain $CaCO_3$ particles. Fig.1 showed carbonation processing. Particles of $CaCO_3$ then characterized by Energy Dispersive Spectroscopy (EDS), and X-Ray Diffraction (XRD).

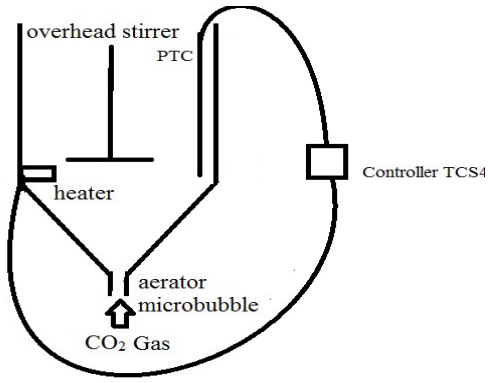

Figure 1. Carbonation or CO_2 bubbling method

Hypothesis of reactions described below:

Calcination :Lime stone $(CaCO_3)_{(s)}$ $^{900^oC}CaO_{(s)} + CO_{2(g)}$

Hidration : $CaO_{(s)} + H_2O_{(l)}$ à*slaked lime* $Ca(OH)_{2(s)}$

Carbonation : $Ca(OH)_{2(s)} + CO_{2(g)}$ à $CaCO_{3(s)} + H_2O_{(l)}$

Detailed reaction of carbonation [11]:

$CO_{2(g)}$ à $CO_{2(aq)}$

$CO_{2(aq)} + H_2O$ à $H_2CO_{3\,(aq)}$

$H_2CO_3(aq)$ à $H^+ + HCO_3^-$

HCO_3^-à $H^+ + CO_3^-$

$Ca^{2+} + CO_3^{2-}$à $CaCO_{3(s)}$

RESULTS

Carbonation process is runfor 15 minutes until the suspension gets neutral pH (6, 5). Initial CaO mass is 84 gr and final $CaCO_3$ mass is 90,90 gr.

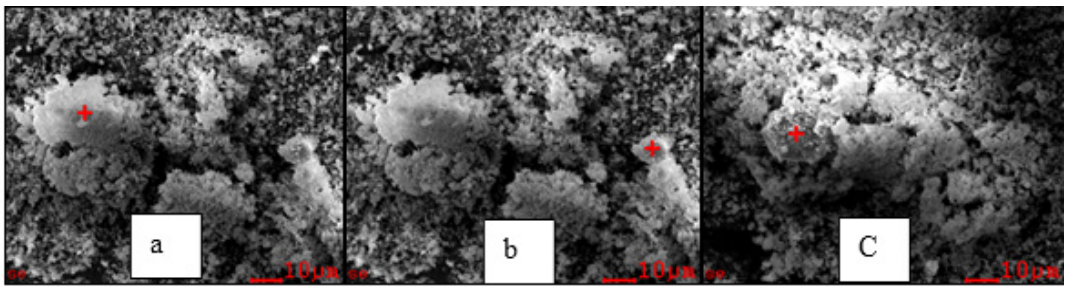

Figure 3. Three dots, during EDS characterization

Table 1. EDS result of $CaCO_3$

	A		B		C	
Element	Weight%	Atomic %	Weight%	Atomic %	Weight %	Atomic %
C	13,07	21,31	2,39	20,61	10,12	17,52
O	49,22	60,26	47,59	59,44	45,89	59,66
Ca	37,71	18,43	40,02	19,95	43,99	22,83

Energy Dispersive Spectroscopy showed elements forming was $CaCO_3$.

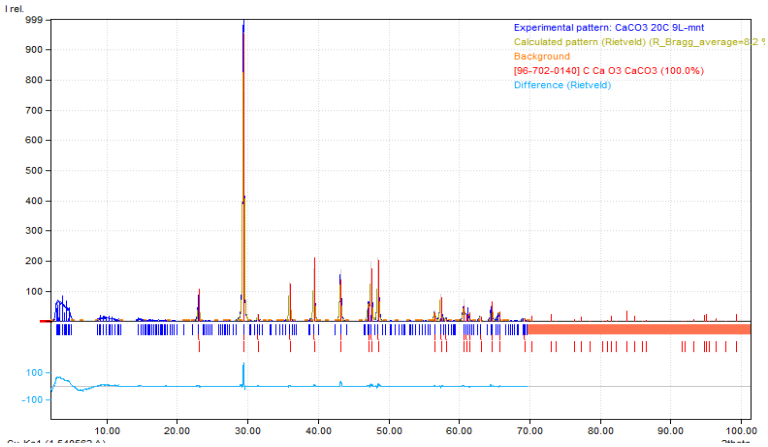

Figure 4. XRD pattern of $CaCO_3$

X-Ray Diffraction pattern of $CaCO_3$ produced trigonal calcite crystalline structure with 2.737g/cm^3 density. Fig.4 showed that the particles are 100% $CaCO_3$ with their peaks. The highest peak is at 2θ degree 30º. This peak same as peak of $CaCO_3$ in reference.

DISCUSSION

$CaCO_3$ morphology result from this research is different from another research which shows that aragonite is formed at temperature 60ºC.Beside, in this research XRD pattern showed calcite formation at the same temperature [12]. Temperaturealso influences particle size of $CaCO_3$ [8]. Small particle (1,5µm) of $CaCO_3$ is formed at 25ºC and the size increases due to agglomeration at 35ºC and at 50ºC particles begin non agglomerate until reach smallest particle size 1,2 µm at 60ºC [8].

Biomedical products that can be obtain from this research are $CaCO_3$ and $Ca(OH)_2$. These products can be utilized as dental product when the products meet each standard like physical properties, mechanical propeties, and biocompatibilty of the materials. Futher research is needed to investigate if these materials are eligible as the desired materials

$CaCO_3$ which used in dentrifrices is different from $CaCO_3$used as other dental materials. $CaCO_3$ is widely used as dentifrices which are act as abrasive materials to remove plaque or stain and polish tooth surface. A discussion of dentrifrices would not be complete without mentioning of the ADA acceptance program for these materials like abrasivity value of 250 (also limit for ISO standard) [13].

Recent research showed $CaCO_3$ role as precursor of carbonate apatite based bone cement and drug delivery system for osteomyelitis disease [1,14]. $CaCO_3$ acts as donor of $CO_3^-$and Ca^{2+}that has similarity with inorganic content of bone [14]. $CaCO_3$ shows unique advantages due to the potentioal and its ideal biocompatibility as delivery system for loading different categories of drugs. $CaCO_3$ is nominated as suitable drug delivery carier bacause of their accessibility, slow biodegradabability, osteoconductivity, safety, low cost, pH-sensitive properties and biocompability [1].

Another product that can be found in this research is $Ca(OH)_2$ which is widely known for it's application in pulp protection as cement base materials [13].

CONCLUSION

$CaCO_3$is successfully synthesized by CO_2 bubbling method. Hopefullly this $CaCO_3$ particles might be used widely in biomedical application. Further study is awaited based on these initial findings.

ACKNOWLEDGEMENT

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