Potential of Clay in Coal Mining of Tanjung Enim Area as a Filler on Rubber Compound

A Hasan¹,², L Kalsum¹, M Yerizam¹, R Junaidi¹, M Taufik¹, M Aznury¹, and Fatria¹

¹ Chemical Engineering Department, State Polytechnic of Sriwijaya, Srijaya Negara Street, Bukit Besar Palembang 30139, Indonesian
abu_hasan@polsri.ac.id

Abstract. The clay deposit in the coal mining area of Tanjung Enim has a deposit about five times its coal deposit. This clay has not been utilized except as glue on brick briquettes which are relatively small quantities. As a rubber filler, clay can be used, but the silica content is preferred in the clay. Therefore the composition of silica in clay must be known. This study aims to determine the content of silica in the clay contained in the coal mining area of Tanjung Enim. The research begins with clay drying, followed by the fineness of clay grain size to a size of about 10-50 microns. Furthermore, the analysis of the compounds there in is carried out using XRF. The results show that the silica content in the clay is about 53.74 - 75.29% and the highest content is in the Lower D layer 75.29% and followed by the Int B2-C layer 56.87% and Lower C 56.65 %. In general, the compounds in this clay are dominated by SiO₂, Al₂O₃, Fe₂O₃, MgO, TiO₂, and K₂O.

1. Introduction

Coal mining area in the Tanjung Enim, South Sumatra Province of Indonesian not only benefits coal mining companies in Tanjung Enim itself but also clay deposits located between coal layers are also quite promising to be explored and investigated. This clay is only a small portion used by PT Bukit Asam (Persero) Tbk. as briquette coal adhesive in addition to the reclamation of the surrounding mining area after the mining process. The total amount of clay deposits in the coal mining area is five times more than coal deposits.

In the design of rubber compounds, fillers are needed [1-4] especially to improve their physical properties and are very important. Research on the use of clay as a filler for rubber compounds has been widely practiced and includes modification of clay [5-32] but in Indonesia clay fillers for rubber have not been considered and most are still imported from abroad. Most of the clay in Indonesia is used as raw material for making pottery, cement raw materials and as an adsorbent [33-38]. Bond (1951), Schenck et. al. (1964), and Goodman and Riley (2012) [39-41] even patented local clay as a filler for rubber compounds. Another study of clay, as a catalyst in chemical processes, for example, was carried out by Adams et. Al. (1982), Xu et. Al. (2009), Nagendrappa (2011), Solak and Rutkowski (2014), Sirsam and Usmani (2015), and Bosco et. Al. (2016) [42-47]. Here it is seen that clay is very important to be investigated by paying attention to its compound content. The use of clay as a rubber filler can also reduce CO₂ emissions where carbon black which still dominates fillers in rubber products is produced with imperfect combustion process conditions of heavy fractions such as fluid catalytic cracking of tar, coal tar, ethylene tar crack, and with little comes from vegetable oil.
As a filler, the content of silica (SiO$_2$) in clay needs to be considered, because silica can have a significant effect on rubber vulcanization and improve its physical properties. Thus, the silica content in clay is interesting to study.

2. Materials and methods

2.1. Materials

The main material used in this research is clay contained in the coal mining area of PT Bukit Asam (Persero) Tbk. Tanjung Enim, South Sumatra Province in seven layers of clay.

2.2. Methods

The research method consists of sample preparation and testing of elemental content or compounds contained in the clay. Drying of the clay at 110°C for about 2 hours and followed by smoothing the sample until the clay has a size of about 10 - 50 microns. Preparation of this sample is done in Chemical Laboratory of Chemical Engineering Department of State Polytechnic of Sriwijaya. Further analysis of compounds in clay is done by using Uniquant XRF Bruker S8 Tiger owned by PT Cement Indonesia (Persero) Tbk.

3. Results and discussion

Analysis of compounds contained in the clay at coal mining area of Tanjung Enim, South Sumatra Province using XRF according to its layer is shown in table 1.

| Component | OB Lower | Int Lower | Int A1-A2 | Int A2-B1 | Int B1-B2 | Int B2-C | C Lower | Lower D |
|-----------|----------|-----------|-----------|-----------|-----------|----------|---------|---------|
| SiO$_2$   | 53.74%   | 55.22%    | 50.83%    | 54.31%    | 56.87%    | 56.65%   | 75.29%  |         |
| Al$_2$O$_3$ | 25.05%  | 26.22%    | 24.87%    | 21.49%    | 21.49%    | 20.32%   | 7.62%   |         |
| Fe$_2$O$_3$ | 4.90%   | 1.45%     | 3.28%     | 4.97%     | 3.45%     | 6.22%    |         | 7.25%   |
| TiO$_2$   | 0.90%    | 0.79%     | 1.03%     | 0.90%     | 0.90%     | 0.87%    | 0.33%   |         |
| MgO       | 1.52%    | 0.68%     | 0.40%     | 1.19%     | 0.67%     | 1.79%    | 1.82%   |         |
| K$_2$O    | 1.84%    | 0.46%     | 1.04%     | 1.55%     | 1.75%     | 2.02%    | 0.92%   |         |
| CaO       | 0.48%    | 0.38%     | 0.26%     | 0.69%     | 0.26%     | 0.66%    | 0.74%   |         |
| Na$_2$O   | 0.12%    | 0.07%     | 0.06%     | 0.12%     | 0.13%     | 0.39%    | 0.44%   |         |
| SO$_3$    | 1.24%    | 0.51%     | 3.07%     | 1.86%     | 3.02%     | 2.09%    | 0.22%   |         |
| MnO       | 0.12%    | 0.01%     | 0.02%     | 0.11%     | 0.01%     | 0.07%    | 0.05%   |         |
| P$_2$O$_5$| 0.05%    | 0.05%     | 0.04%     | 0.06%     | -         | 0.08%    | 0.10%   |         |
| Cr$_2$O$_3$| 0.01%   | 0.03%     | 0.03%     | 0.05%     | 0.05%     | 0.07%    | 0.16%   |         |
| Others    | 10.03%   | 14.13%    | 15.07%    | 12.70%    | 11.40%    | 8.77%    | 5.06%   |         |

Table 1. shows that the compounds contained in the clay are dominated by SiO$_2$, Al$_2$O$_3$, Fe$_2$O$_3$, MgO, TiO$_2$, and K$_2$O but in terms of quantity SiO$_2$ is the most compound found in various layers in clay around 53.74 - 75.29% followed by Al$_2$O$_3$ content of about 7.62 - 26.22%, and the third largest was Fe$_2$O$_3$ 1.45 - 7, 25%. The highest SiO$_2$ content is in the Lower D layer of about 75.29%, and the lowest in the Int A2-B1 layer is about 50.83% while the highest Al$_2$O$_3$ content in the Int A1-A2 layer is in the range of 26.22% and the lowest in the Lower D layer in the range of 21.49%. The content of SiO$_2$, Al$_2$O$_3$, Fe$_2$O$_3$ in this clay can also be compared with the results of analysis using SEM-EDS conducted by Hasan and Taufik in 2014 [48], Hasan et.al. in 2015 using XRD [49], and by Konta (1963), Herziq et. al. in 1998, as well as Muriithi et.al. (2012), and Jeong and Achterberg (2014) [50-53]. The results of these researchers showed different results depending on where the clay source was obtained. For comparison,

2
the quantitative clay mineral analysis using XRD is shown in figure 1. From this figure, the silica content is 77.84% as quartz mineral followed by another muscovite 11.15% and microcline 3.71%. High silica content is very interesting, because silica is not only used as a filler on rubber but also for catalysts such as silica is used as catalyst support such as Min et al. (2003), Kababji et al. (2009), and Dixit et. al. (2013) [54-56] and as a catalyst mixture which included Irurzun et al. (2009), Ray et al. (2015), and Adamson et al. (2004) [57-59].

![Figure 1. Quantitative analysis of clay using XRD performed by Hasan et. al. (2015) [49]](image)

4. Conclusions
The conclusion obtained from this research is the silica content of clay in the coal mining area of PT Bukit Asam (Persero) Tbk. in the Lower D layer is 75.29%. Not only silica, but the content of alumina and iron oxide is also quite high content. In general, the silica content in each layer ranges from 53.74 to 75.29%

5. References
[1] Andrews E H 1963 Rubber Chemistry and Technol. 36 325-36.
[2] Morton M 1987 Rubber Technology (New York: Van Nostrand Reinhold) Chapter 3 Part II
[3] Yu L 2009 Biodegradable Polymer Blends and Composites from Renewable Resources (Jhon Wiley and Sons) Chapter 17.
[4] Mujkanovic A, Vasiljevic L, and Ostojic G 2009 Non-Black Fillers For Elastomers. 13th International Research/Expert Conference “Trends In The Development Of Machinery And Associated Technology” TMT 2009, Hammamet, Tunisia, 16-21 October 2009
[5] Uddin F 2008 Metallurgical and Materials Transactions A. 39A 2804-14
[6] Ambre A, Jagtap R, and Dewangan B 2008 Journal of Reinforced Plastics and Composites 28 343-52.
[7] Sukumar R and Menon A R R 2008 J. of Applied Polymer Science 107 3476–83 (2008)
[8] Yahaya L E, Adebawale K O, and Menon A R R 2009 Applied Clay Science 46 283–8
[9] Jia D, Liu L, Wang X, Guo B, and Luo Y 2009 Edited by Long Yu (John Wiley & Sons, Inc.) CHAPTER 17, 416-33
[10] Liu Y, Li L, and Wang Q 2010 Journal of Applied Polymer Science 118 1111–20
[11] Zhang Y, Liu Q, Zhang Q, and Lu Y 2010 Applied Clay Science 50 255-9
[12] Albano C, Hernandez M, Ichazo M N, Gonzalez J, and DeSausa W 2011 Polym. Bull. 67 653-67
[13] Panwar A, Choudhary V, and Sharma D K 2011 J. of Reinforced Plastics and Composites 30 446-59.
[14] Ismail H and Mathialagan M 2011 Polymer-Plastics Technology and Engineering 50 1421–28
[15] Lalikova S, Pajtasova M, Chromcikova M, Liska M, Sutinska V, Olsovsky M, Ondrusova D, and Mojumdar S C 2011 J Therm Anal Calorim 104 969–73
[16] Albano C, Rodriguez B, Karam A, Hernandez M, Ichazo M N, Gonzalez J, and Covis M 2012 Polym. Bull. 68 1935-50
[17] Goodman H and A. Riley A 2012 US8183316 B2
[18] Saritha A, Joseph K, Thomas S, and Muraleekrishnan R 2012 J. of Applied Polymer Science 124 4590–7
[19] Zhang Q, zhang Y and Wang Y 2012 Applied Mechanics and Materials 164 142-5
[20] Jagtap S B, Rao V S, and Ratna D 2013 Journal of Reinforced Plastics and Composites 32 183-96.
[21] Szustakiewicz K, Cichy B, Gazińska M, and Piggłowski J 2013 J. of Reinforced Plastics and Composites 14 1005-17.
[22] Harahap H, Surya I, Ismail H, Kamil E, Khoesoema E, and Surya E 2013 Paper Presented On The 11th International Conference On Mining, Materials And Petroleum Engineering And The 7th International Conference On Earth Resources Technology. Asean Forum On Clean Coal Technology. Chiang Mai Thailand. 15-9
[23] Zhang Y, Zhang Q, Liu Q, Cheng H, and Frost R L 2014 J Therm Anal Calorim. 115 1013–20
[24] Ruamcharoen J, Ratana T, and Ruamcharoen P 2014 Polymer Engineering And Science 54 1436-43
[25] Ogbebor O J, Oikiemen F E, Ogbeifun D E, and Okwo U N 2015 Chem. Ind. Chem. Eng. 4 477-84
[26] Ogbebor O J, Oikiemen F E, Ogbeifun D E, and Okwo U N 2015 Advance in Materials 4 75-9
[27] Puglia D, Fortunati E, D’Amico D A, Miri V, Stoclet G, Manfredi L B, Cyiras V P, and Kenny J M 2016 J Polym Environ. 1 12–22
[28] Sheikh S H, Yin X, Ansyarifar A, and Yendall K 2017 J Reinforced Plastic and Composites 36 1132-45
[29] Sreelekshmi R V, Brahmakumar M, Sudha J D, and Menon A R R 2017 Applied Clay Science 141 171–9
[30] Kord B, Ravanfar P, and Ayrilmis N 2017 J Polym Environ. 25 1198–1207
[31] Sreelekshmi RV, Sudha J D, and Menon A R R 2017 Polym. Bull. 74 783–801
[32] Peter R, Sreelekshmi R V, and Menon A R R 2018 J Polym. Environ. 26 39-47
[33] Nufida B A, Kurnia N, and Kurniasih Y 2014 Prosiding of Seminar Nasional Kimia, Jurusan Kimia Fmipa Universitas Negeri Surabaya, 20 September 2014
[34] Hsu Y C, Chiang C C, and Yu M F 1997 Separation Science and Technology 32 2513-34
[35] Diantariani N P 2010 Jurnal Kimia 4 91-100
[36] Priadi C R, Anita, Sari P N, and Moersidik S S 2014 Reaktor 15 10-19
[37] Kausar A, Iqbal M, Javed A, Aftab K, Nazli Z H, Bhatti H N, and Nouren S 2018 J. of Molecular Liquids 256 395-407
[38] Adeyemo A A, Adeoye I O, and Bello O S 2017 Applied Water Science. 7 543–68
[39] Schenck L M, Harry K, Hodgkiss J A 1964 https://patents.google.com/patent/US3148158A/en (accessed April, 16th 2018)
[40] Bond J G R 1951 https://patents.google.com/patent/US2551580A/en (accessed April, 16th 2018)
[41] Goodman H and Riley A 2012. Clay Mineral Products and Their Use in Rubber Compositions. US8183316 B2
[42] Adams J M, Clement D E, and Graham S H 1982 Clay and clay minerals. 30 129-34
[43] Xu H Y, He X L, Wu Z, Shan L W, and Zhang W D 2009 Bull. Korean Chem. Soc. 30 2249-52
[44] Nagendrappa G 2011 Applied Clay Science 53 106-8
[45] Solak A and Rutkowski P 2014 Waste Management. 34 504-12
[46] Sirsam R and Usmani G 2015 Int. J. of Research in Eng. and Tech. 4 144-50
[47] Bosco S M D, Gonçalves M, Figueiredo F C A, Galhardo T, and Carvalho W A 2016 Waste and Biomass Valorization. 7 1279–88
[48] Hasan A and Taufik M 2014 Karakterisasi Awal Unsur Yang Ada Pada Tanah Liat Di PT. Bukit Asam (Persero) Tbk. Menggunakan SEM. (State Polytechnic of Sriwijaya: Research report, unpublished)
Acknowledgments

Acknowledgments are addressed to DRPM Kemenristekdikti through PTUPT 2017 fiscal year with contract number PUPT 050 / SP2H / LT / DRPM / IV / 2017 dated 25 April 2017. Acknowledgments are also addressed to PT Bukit Asam (Persero) Tbk. for the aid of clay samples, and PT Cement Indonesia (Persero) Tbk. especially the Central Research Laboratory of Cement that assists the analysis using XRF.