Manufacturing Technique of Temporary Dental Filling Composite

Ching-Wen Lou[1,c]*, Chao-Tsang Lu[2,b]*, Shih-Yu Huang[1], Po-Ching Lu[3], Tzu-Hsuan Chao[3] and Jia-Horng Lin[3,4,a]*

[1]Institute of Biomedical Engineering and Material Science, Central Taiwan University of Science and Technology, Taichung 406, Taiwan, R.O.C.

[2]Institute of Life Sciences, Central Taiwan University of Science and Technology, Taichung 406, Taiwan, R.O.C.

[3]Laboratory of Fiber Application and Manufacturing, Department of Fiber and Composite Materials, Feng Chia University, Taichung City 407, Taiwan, R.O.C.

[4]School of Chinese Medicine, China Medical University, Taichung 40402, Taiwan, R.O.C.

*corresponding email: [a]jhlin@fcu.edu.tw, [b]ctlu@ctust.edu.tw, [c]cwlou@ctust.edu.tw.

Keywords: polylactic acid (PLA), Zinc oxide, eugenol, dental filling composite

Abstract: Millions of people worldwide have cavities in teeth, thus ranking cavity issue important in global oral health. This study created the temporary dental composite filling material with zinc oxide, eugenol solvent, and polylactic acid (PLA) fibers. Zinc oxide and eugenol (IRM®) were blended with a weight ratio of 3:1, after which a variety of PLA fibers (2 wt%, 4 wt%, 6 wt%, 8 wt%, and 10 wt%) were then well mixed with the IRM® solution, completing the IRM®/PLA dental filling composite. The aim of this study was to determine the influence of different contents of PLA fiber on the prepared filling composite, by employing measurements of leakage property, compressive strength, solubility, leakage and setting timer. In particular, when the PLA fibers was 6 wt%, the IRM® /PLA dental filling composite did not have micro-leakage on Day 13.

Introduction

There are four elements (bacteria, environment, host, and time), ascribing to the decayed teeth. Bacteria refer to the pathogens in mouth, especially variant streptococci. Environment is the hosts' oral cavity, which is affected by the oral clean and carbohydrate majorly. Host is influenced by if the tooth has solubility to acid, saliva amount, arrangements of teeth and genetic factors. Time means the interval duration for enamel displaying decalcification when the pH value in oral cavity is lower than 5.2. Mattila et al. (2005) conducted an area survey, revealing that children with worse oral hygienic habit encounter a higher risk of decayed tooth. Oral health is primarily affected by irregular cleaning habit and dental plaque, thus correct oral habit and knowledge help reduce the cavity risk [3]. Many vivo studies have been done to examine various filling materials and techniques. The micro-leakage measurement is frequently used, involving a) dye leakage method, b) fluid filtration method, c) microorganism penetration method, d) electrochemical method, and e) radioisotope labeling method. The first three methods are popular, among which the dye leakage method is the easiest. None of those methods can replicate the complicated root-end infection

mechanism, so it is hard to tell which one is of the best [4-12]. The purpose of this study was to determine if the physical and chemical structure of IRM® solution would be changed by the addition of PLA fibers according to measurements of setting time, solubility, micro-leakage and compressive strength, and further determined the future application of the resulting IRM®/PLA dental filling composite in dental field.

Experimental

Low-melting-point PLA fiber (melting point: 130 ˚C; fineness: 2 Denier; length: 50mm; elongation: 52 %) was offered by Far Eastern New Century Corporation. IRM® (Densply) was composed of zinc-oxide powder and the eugenol solvent with a weight ratio of 3:1 and stirred for 1 minute, after which PLA fibers (trimmed length: 2mm; weight ratio: 2, 4, 6, 8, and 10 wt%) were well mixed IRM® solution. Then the IRM® /PLA mixture was pour into a mold with a 4 mm diameter and a 6mm length and then left to solidify into an IRM® /PLA dental filling composite. The measurements of setting time, solubility, micro-leakage, and compressive strength were conducted in accordance with American Dental Association (ADA) #30.

Results and discussion

Setting Time

Table 1 presents the setting time for IRM® /PLA dental filling composite based on different contents of PLA fiber. Setting time decreased with the increase in the content PLA fiber. When added into the IRM® solution, PLA fiber would absorb a few amount of eugenol solvent, decreasing the eugenol to interact with zinc-oxide, so the setting time became shorter.

Table 1. Setting time for IRM® /PLA dental filling composite with different contents of low-melting-point PLA fibers.

Content of PLA fiber (wt%)	Setting time (sec)
0	786 ± 13
2	557 ± 17
4	555 ± 25
6	519 ± 09
8	501 ± 21
10	485 ± 30

Solubility

Figure 1 illustrates the solubility of IRM®/PLA dental filling composite with different contents of PLA fiber on Day 1, 7 and 13. It could be seen that when dental composite was soaked for a longer duration, its solubility ascended. As when the soaking duration was in an increase, the specimens started to dissolve; the longer the soaking duration, the more amount the dental composite dissolve. Different content of PLA fiber did not show an influence on the solubility of the dental composite, neither on a certain trend of increase or of decrease of the solubility, as exemplified in Figure 1. This phenomenon could be ascribed to the addition of the PLA fiber, which

was not influential to the component of IRM®, thus PLA fiber did not exhibit an influence on IRM® /PLA dental filling composite.

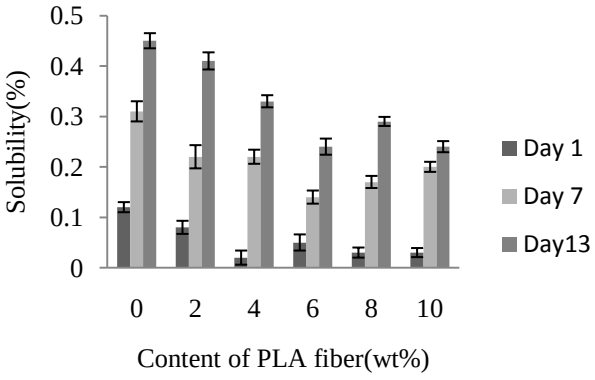

Figure 1. The solubility of IRM® /PLA dental filling composite with varying contents of PLA fiber on Day 1, 7, and 13.

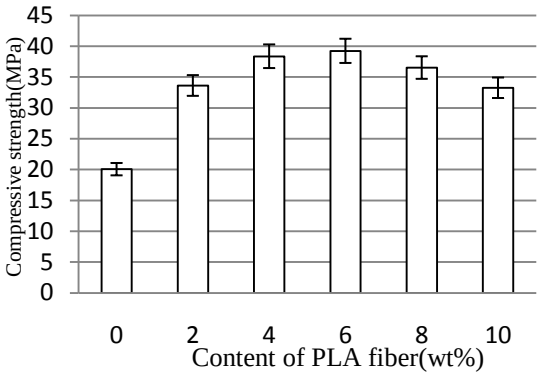

Figure 2. The compressive strength of IRM® /PLA dental filling composite with varying contents of PLA fiber on Day 13.

Compressive Strength

Figure 2 shows the influence of the varying contents of PLA fiber on the compressive strength of IRM® /PLA dental filling composite. When added with more PLA fiber, IRM® /PLA dental filling composite exhibited a higher compressive strength. However, when the weight ratio of PLA fiber exceeded 6 wt%, the compress strength of the dental composite started declining. An increase in PLA fiber contributed to a distinct reinforcement of the dental composite. Nevertheless, the excess addition of PLA fiber above 6 wt% brought about the interface problem between the PLA fiber and IRM®, causing the stress concentration in the filling composite, whose compressive strength was decreased accordingly.

Micro-Leakage

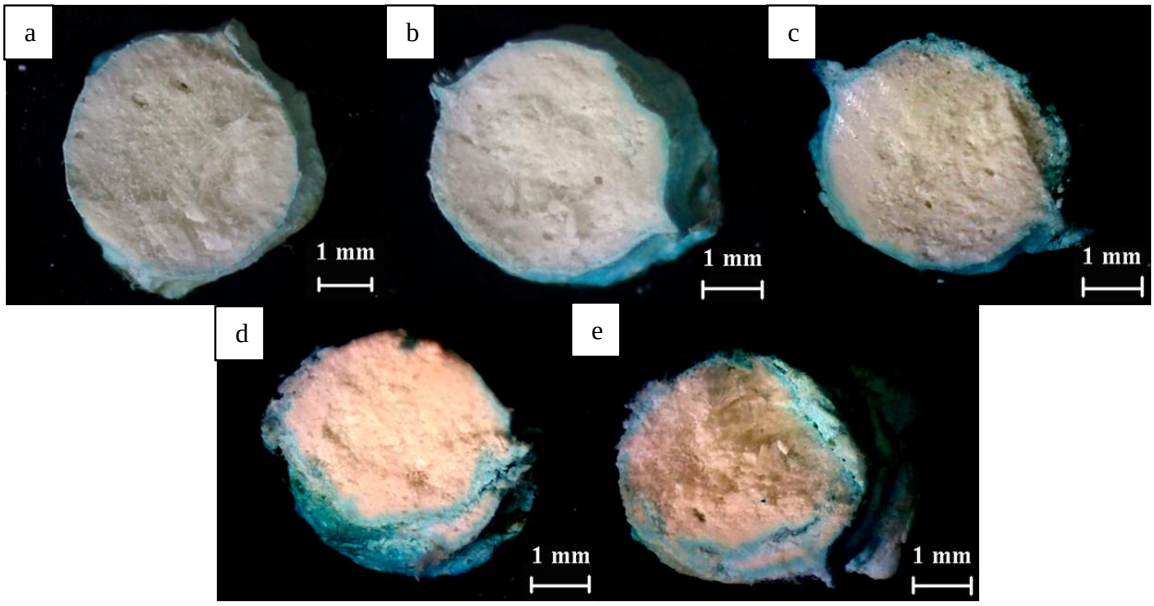

Figure 3. The micro-leakage photos (12X) of IRM® /PLA dental filling composite with varying contents of PLA fiber on Day 13; (a) 2 wt%, (b) 4 wt%, (c) 6 wt%, (d) 8 wt%, (e) 10 wt%.

Figure 3 demonstrates the photos of the contents of PLA fiber on micro-leakage of IRM®/PLA dental filling composite by a zoom stereo microscope. Not until the content of PLA fiber was over 6 wt%, could the micro-leakage of IRM®/PLA dental filling composite be observed, proving that the dental filling composite possessed a good sealing when with 2, 4, 6 wt% PLA fiber. When there was over 6 wt% of PLA fiber, IRM® failed in completely immersing the PLA fibers, dye easily penetrated the interior of the filling composite from its pores on the surface.

Conclusion

Base on setting time measurement, setting time was decreased by 38 % with an increase in PLA fiber of the IRM®/PLA dental filling composite, but the shortage of time did not affect the sample preparation. According to compressive strength, adding 6 wt% of PLA fibers heightened the compressive strength of the filling composite by 110 %. With regard to solubility measurement, the addition of PLA fiber did not exhibit a distinct increasing or decreasing influence on composite. Based on the micro-leakage measurement, the IRM®/PLA dental filling composite exhibited a micro-leakage when the composite was added with over 6 wt% PLA fiber.

Acknowledgement

This work would especially like to thank National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract NSC 99-2622-E-039-004-CC3.

References

[1] M.L. Mattila, P. Rautava, M. Aromaa, A. Ojnlatva, P. Paunio, L. Hyssala and H. Helenius: Caries Res Vol. 39(2005), p. 85-91.

[2] H.I. Copeland, G.M. Brauer, W T. Sweeney and A.F. Forziati: J. Res N.B.S Vol. 55(1955), p. 134-138.

[3] M.M. Gerner, B.A. Zandorozhnnyi, L.V. Ryabina, V.N. Batovskii and V.I. Scharchilev: J. Phys. Chem Vol. 40(1966), p. 122.

[4] M.K. Wu, E. Kontakiotis and P.R.Wesselink: J Endodon Vol. 24(1998), p. 557–560.

[5] F.D. Bou and G. Yared: J Endodon Vol. 21(1995), p. 335–336.

[6] K.G. Antonopoulos, T. Attin and E. Hellwig: J Endodon Vol. 24(1998), p.655–658.

[7] S.G. Forte, M.J. Hauser, C. Hahn and G.R Hartwell: J Endodon Vol. 24(1998), p.799–801.

[8] B. Jacquot, M. Panighi, P. Steinmetz and C.G'Sell J Endodon Vol. 22(1996), p.586–589.

[9] P.M. Michaïlesco, J. Valcarel, A.R.Grieve, B. Levallois and D. Lerner J Endodon Vol.22(1996), p.535–539.

[10] Y. Haïkel, W. Wittenmeyer, G. Bateman, A. Bentaleb and C. Allemann J Endodon Vol. 25(1999), p.172–178.