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Effect of Plastic Deformation on the Structure and Properties of the Bioresorbable Zinc Alloy Zn-0.8Li-0.1Mn

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Abstract. The study of bioresorbable alloys is a relevant and promising area. Zinc alloys, in particular, are very promising for bioresorbable applications since zinc is an inexpensive and widely available material. In this paper, studies of the effect of plastic deformation by rolling on the zinc alloy Zn-0.8Li-0.1Mn are conducted. This alloy demonstrates high mechanical properties as a result of hot rolling treatment: ultimate tensile strength and yield strength are 525 MPa and 445 MPa, respectively, and elongation is 7%. The alloy structure is examined using modern methods such as scanning electron microscopy and electron backscattering diffraction. The results of the study can be useful for further research in the field of new materials development, as well as for the practical application of zinc alloys in various industries.

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View Table of Contents: https://reviewsamt.com/issues

REFERENCES

[1] M. Saini, Y. Singh, P. Arora, V. Arora, K. Jain K., Implant biomaterials: A comprehensive review, *World Journal of Clinical Cases*, 2015, vol. 3, no. 1, pp. 52–57.

[2] H.F. Li, X.H. Xie, Y.F. Zheng, Y. Cong, F.Y. Zhou, K.J. Qiu, X. Wang, S.H. Chen, L. Huang, L. Tian, L. Qin, Development of biodegradable Zn-1X binary alloys with nutrient alloying elements Mg, Ca and Sr, *Scientific Reports*, 2015, vol. 5, art. no. 10719.

[3] K. Kaur, R. Gupta, S.A. Saraf, S.K. Saraf, Zinc: the metal of life, *Comprehensive Reviews in Food Science and Food Safety*, 2014, vol. 13, no. 4, pp. 358–376.

[4] G.E.J. Poinern, S. Brundavanam, D. Fawcett, Biomedical magnesium alloys: a review of material properties, surface modifications and potential as a biodegradable orthopaedic implant, *American Journal of Biomedical Engineering*, 2012, vol. 2, no. 6, pp. 218–240.

[5] N. Hort, Y. Huang, D. Fechner, M. Störmer, C. Blawert, F. Witte, C. Vogt, H. Drücker, R. Willumeit, K.U. Kainer, F. Feyerabend, Magnesium alloys as implant materials–principles of property design for Mg–RE alloys, *Acta Biomaterialia*, 2010, vol. 6, no. 5, pp. 1714–1725.

[6] F. Witte, N. Hort, C. Vogt, S. Cohen, K.U. Kainer, R. Willumeit, F. Feyerabend, Degradable biomaterials based on magnesium corrosion, *Current Opinion in Solid State and Materials Science*, 2008, vol. 12, no. 5–6, pp. 63–72.

[7] M. Schinhammer, A.C. Hänzi, J.F. Löffler, P.J. Uggowitzer, Design strategy for biodegradable Fe-based alloys for medical applications, *Acta Biomaterialia*, 2010, vol. 6, no. 5, pp. 1705–1713.

[8] S.F. Mousavi, H. Sharifi, M. Tayebi, B. Hamawandi, Y. Behnamian, Thermal cycles behavior and microstructure of AZ31/SiC composite prepared by stir casting, *Scientific Reports*, 2022, vol. 12, no. 1, art. no. 15191.

[9] D.A. Aksenov, E.I. Fakhretdinova, R.N. Asfandiyarov, A.G. Raab, A.E. Sharipov, M.A. Shishkunova, Yu.R. Sementeeva, Changes in the structure, mechanical and corrosionproperties of the Mg–Zn–Zr system alloy subjected to equal channel angular pressing, *Frontier Materials & Technologies*, 2024, no. 1, pp. 9–17.

[10] J.W. Lee, H.S. Han, K.J. Han, J. Park, H. Jeon, M.R. Ok, H.K. Seok, J.P. Ahn, K.E. Lee, D.H. Lee, Long-term clinical study and multiscale analysis of in vivo biodegradation mechanism of Mg alloy, *The Proceedings of the National Academy of Sciences of the United States of America*, 2016, vol. 113, no. 3, pp. 716–721.

[11] X. Liu, J. Sun, K. Qiu, Y. Yang, Z. Pu, L. Li, Y. Zheng, Effects of alloying elements (Ca and Sr) on microstructure, mechanical property and in vitro corrosion behavior of biodegradable Zn–1.5 Mg alloy, *Journal of Alloys and Compounds*, 2016, vol. 664, pp. 444–452.

[12] H. Huang, H. Liu, L. Wang, K. Yan, Y. Li, J. Jiang, A. Ma, F. Xue, J. Bai, Revealing the effect of minor Ca and Sr additions on microstructure evolution and mechanical properties of Zn-0.6 Mg alloy during multi-pass equal channel angular pressing, *Journal of Alloys and Compounds*, 2020, vol. 844, art. no. 155923.

[13] Y. Shi, L. Yang, L. Wang, Q. Zhang, X. Zhu, W. Sun, J. Shen, T. Lu, Z. Song, H. Liu, Corrosion and biocompatibility of pure Zn with a micro-arc-oxidized layer coated with calcium phosphate, *Coatings*, 2021, vol. 11, no. 11, art. no. 1425.

[14] P. Guo, F. Li, L. Yang, R. Bagheri, Q. Zhang, B.Q. Li, K. Cho, Z. Song, W. Sun, H. Liu, Ultra-fine-grained Zn-0.5Mn alloy processed by multi-pass hot extrusion: Grain refinement mechanism and room-temperature superplasticity, *Materials Science and Engineering: A*, 2019, vol. 748, pp. 262–266.

[15] J. Lin, X. Tong, K. Wang, Z. Shi, Y. Li, M. Dargusch, C. Wen, Biodegradable Zn-3Cu and Zn-3Cu-0.2Ti alloys with ultrahigh ductility and antibacterial ability for orthopedic applications, *Journal of Materials Science & Technology*, 2021, vol. 68, pp. 76–90.

[16] S. Zhang, X. Zhang, C. Zhao, J. Li, Y. Song, C. Xie, H. Tao, Y. Zhang, Y. He, Y. Jiang, Y. Bian, Research on an Mg–Zn alloy as a degradable biomaterial, *Acta Biomaterialia*, 2010, vol. 6, no. 2, pp. 626–640.

[17] R.A. Bekker, Yu.V. Bykov, Lithium Preparations in Psychiatry, Addiction Medicine and Neurology. Part II. Biochemical Mechanisms of Its Action, *Acta Biomedica Scientifica*, 2019, vol. 4, no. 2, pp. 80–100.

[18] J.B. Jurakulov, The most important importance of the manganese element in the human body, *International Journal of Advanced Research in Education, Technology and Management*, 2024, vol. 3, no. 1, pp. 44–47.

[19] L. Kong, Z. Heydari, G.H. Lami, A. Saberi, M.S. Baltatu, P. Vizureanu, A comprehensive review of the current research status of biodegradable zinc alloys and composites for biomedical applications, *Materials*, 2023, vol. 16, no. 13, art. no. 4797.

[20] S. Zhao, J.-M. Seitz, R. Eifler, H.J. Maier, R.J. Guillory II, E.J. Earley, A. Drelich, J. Goldman, J.W. Drelich, Zn-Li alloy after extrusion and drawing: structural, mechanical characterization, and biodegradation in abdominal aorta of rat, *Materials Science and Engineering: C*, 2017, vol. 76, pp. 301–312.

[21] G. Bao, Q. Fan, D. Ge, K. Wang, M. Sun, Z. Zhang, H. Guo, H. Yang, B. He, Y. Zheng, In vitro and in vivo studies to evaluate the feasibility of Zn-0.1 Li and Zn-0.8 Mg application in the uterine cavity microenvironment compared to pure zinc, *Acta Biomaterialia*, 2021, vol. 123, pp. 393–406.

[22] H. Yang, X. Qu, M. Wang, H. Cheng, B. Jia, J. Nie, K. Dai, Y. Zheng, Zn-0.4Li alloy shows great potential for the fixation and healing of bone fractures at load-bearing sites, *Chemical Engineering Journal*, 2021, vol. 417, art. no. 129317.
[23] Z. Li, Z.-Z. Shi, Y. Hao, H.-F. Li, X.-F. Liu, A.A. Volinsky, H.-J. Zhang, L.-N. Wang, High-performance hot-warm rolled Zn-0.8Li alloy with nano-sized metastable precipitates and sub-micron grains for biodegradable stents, *Journal of Materials Science & Technology*, 2019, vol. 35, pp. 2618–2624.
[24] R.Z. Valiev, A.P. Zhilyaev, T.G. Langdon, *Bulk Nanostructured Materials: Fundamentals and Applications*, John Wiley & Sons, Inc., Hoboken, 2013.
[25] M. Ataka, Rolling Technology and Theory for the Last 100 Years: The Contribution of Theory to Innovation in Strip Rolling Technology, *ISIJ International*, 2014, vol. 55, no. 1, pp. 94–107.
[26] Z. Song, R. Niu, X. Cui, E.V. Bobruk, M.Yu. Murashkin, N.A. Enikeev, J. Gu, M. Song, V. Bhatia, S.P. Ringer, R.Z. Valiev, X. Liao, Mechanism of Room-Temperature Superplasticity in Ultrafine-Grained Al–Zn Alloys, *Acta Materialia*, 2023, vol. 246, art. no. 118671.
[27] J.A. del Valle, F. Carreno, O.A. Ruano, Influence of texture and grain size on work hardening and ductility in magnesium-based alloys processed by ECAP and rolling, *Acta Materialia*, 2006, vol. 54, pp. 4247–4259.