

Scientific Studies and Literature on: Hydroxyapatite in Dentistry

A. Books, general reviews: Hydroxyapatite

1. Enax, J. & Eppele, M. Synthetic hydroxyapatite as a biomimetic oral care agent. *Oral Health Prev. Dent.* **16**, 7-19 (2018).
2. Enax, J. & Eppele, M. Die Charakterisierung von Putzkörpern in Zahnpasten. *Dtsch. Zahnärztl. Z.* **73**, 100-108 (2018).
3. Eppele, M. & Enax, J. Moderne Zahnpflege aus chemischer Sicht. *Chem. Unserer Zeit* doi:10.1002/ciuz.201800796 (2018, in press).
4. Juntavee, A., Sinagpulo, A.N., Juntawee, N. Modern approach to pediatric dental caries prevention and treatment. *Ann. Ped. Child Health.* **5** (2): 1127.
5. Juntavee, N., Juntavee, A., Plongniras, P. Remineralization potential of nano-hydroxyapatite on enamel and cementum surrounding margin of computer-aided design and computer-aided manufacturing ceramic restoration. *Int. J. Nanomed.* **13**: 2755-2765.
6. Loveren, C. v., Schmidlin, P. R., Martens, L. C. & Amaechi, B. T. Dentin hypersensitivity management. *Clin. Dent. Rev.* **2**, 6 (2018).
7. Meyer, F., Amaechi, B.T., Fabritius, H.O., Enax, J. Overview of Calcium Phosphates used in Biomimetic Oral Care. *Open Dent. J.* (2018, in press).
8. Meyer, F. & Enax, J. Die Mundhöhle als Ökosystem. *Biol. Unserer Zeit* **1**, 62-68 (2018).
9. Meyer, F. & Enax, J. Demografische Entwicklung und häusliche Zahnpflege. *ZWR - Das Deutsche Zahnärzteblatt* **127**, 98-104 (2018).
10. Enax, J. & Meyer, F. Auswirkung von Xerostomie auf die Lebensqualität. *Dental Tribune, German Edition*, **8** (2018).
11. Meyer, F., Fabritius, H.-O. & Enax, J. Spezielle Zahnpflege bei Dentinhypersensibilität. *ZMK* **33**, 865-868 (2017).
12. Sanavia, C. et al. Remineralization strategies in oral hygiene: A position paper of Italian Society of Oral Hygiene Sciences-S.I.S.I.O. Working Group. *Open Dent. J.* **11**, 527-538 (2017).
13. Dorozhkin, S. V. *Calcium orthophosphate-based bioceramics and biocomposites.* (Wiley-VCH, 2016).
14. Dorozhkin, S. V. Calcium orthophosphates (CaPO₄) and dentistry. *Bioceram. Dev. Appl.* **6**, 1-28 (2016).
15. Amaechi, B. T. Remineralization therapies for initial caries lesions. *Curr. Oral Health Rep.* **2**, 95-101 (2015).
16. Clarkson, B. H. & Exterkate, R. A. Noninvasive dentistry: a dream or reality? *Caries Res.* **49 Suppl 1**, 11-17 (2015).
17. Gillam, D. G. *Dentine hypersensitivity: Advances in diagnosis, management, and treatment.* (Springer International Publishing, 2015).
18. Kolmas, J., Groszyk, E. & Kwiatkowska-Róhycka, D. Substituted hydroxyapatites with antibacterial properties. *Biomed. Res. Int.* **2014**, 15 (2014).
19. Pepla, E., Besharat, L. K., Palaia, G., Tenore, G. & Migliau, G. Nano-hydroxyapatite and its applications in preventive, restorative and regenerative dentistry: a review of literature. *Ann. Stomatol.* **5**, 108-114 (2014).
20. Loveren, C. v. *Toothpastes.* Vol. 23 (Karger, 2013).
21. Hannig, M. & Hannig, C. Nanotechnology and its role in caries therapy. *Adv. Dent. Res.* **24**, 53-57 (2012).
22. Rao, A. & Malhotra, N. The role of remineralizing agents in dentistry: a review. *Compend. Contin. Educ. Dent.* **32**, 26-33 (2011).
23. Hannig, M. & Hannig, C. Nanomaterials in preventive dentistry. *Nat. Nanotechnol.* **5**, 565-569 (2010).

23. Hannig, C. & Hannig, M. Natural enamel wear - A physiological source of hydroxylapatite nanoparticles for biofilm management and tooth repair? *Med. Hypotheses* **74**, 670-672 (2010).
24. Roveri, N. & Iafisco, M. Evolving application of biomimetic nanostructured hydroxyapatite. *Nanotechnol. Sci. Appl.* **3**, 107-125 (2010).
25. Roveri, N., Foresti, E., Lelli, M. & Lesci, I. G. Recent advancements in preventing teeth health hazard: the daily use of hydroxyapatite instead of fluoride. *Recent Pat. Biomed. Eng.* **2**, 197-215 (2009).
26. Venegas, S. C., Palacios, J. M., Apella, M. C., Morando, P. J. & Blesa, M. A. Calcium modulates interactions between bacteria and hydroxyapatite. *J. Dent. Res.* **85**, 1124-1128 (2006).
27. Dorozhkin, S. V. & Epple, M. Biological and medical significance of calcium phosphates. *Angew. Chem. Int. Ed.* **41**, 3130-3146 (2002).
28. Chow, L. C., Eanes, E. D. Octacalcium Phosphate. *Monographs in Oral Science* (Ed. Whitford, G. M.), Karger, Vol. 18 (2001).
29. Brown, P. W. & Constantz, B. *Hydroxyapatite and related materials*. (CRC Press, 1994).
30. Cevc, G., Cevc, P., Schara, M. & Skaleric, U. The caries resistance of human teeth is determined by the spatial arrangement of hydroxyapatite microcrystals in the enamel. *Nature* **286**, 425-426 (1980).

B. Scientific papers: Biofilms, plaque, periodontal health, caries

32. Schlagenhauf, U. *et al.* Microcrystalline hydroxyapatite is not inferior to fluorides in clinical caries prevention: a randomized, double-blind, non-inferiority trial. *bioRxiv*, doi:<https://doi.org/10.1101/306423> (2018).
33. Kamath, P., Nayak, R., Kamath, S. & Pai, D. A comparative evaluation of the remineralization potential of three commercially available remineralizing agents on white spot lesions in primary teeth: An in vitro study. *J. Indian Soc. Pedod. Prev. Dent.* **35**, 229-237 (2017).
34. Ebadifar, A., Nomani, M. & Fatemi, S. A. Effect of nano-hydroxyapatite toothpaste on microhardness of artificial carious lesions created on extracted teeth. *J. Dent. Res. Dent. Clin. Dent. Prospects.* **11**, 14-17 (2017).
35. Kensche, A. *et al.* Efficacy of a mouthrinse based on hydroxyapatite to reduce initial bacterial colonisation in situ. *Arch. Oral Biol.* **80**, 18-26 (2017).
36. Harks, I. *et al.* Impact of the daily use of a microcrystal hydroxyapatite dentifrice on de novo plaque formation and clinical/microbiological parameters of periodontal health. A randomized trial. *PloS one* **11**, e0160142 (2016).
37. Hegazy, S. A. & Salama, I. R. Antiplaque and remineralizing effects of Biorepair mouthwash: A comparative clinical trial. *Pediatr. Dent. J.* **26**, 89-94 (2016).
38. Esteves-Oliveira, M., Meyer-Lueckel, H., Wierichs, R. J., Santos, N. M. & Rodrigues, J. A. Caries-preventive effect of anti-erosive and nano-hydroxyapatite-containing toothpastes in vitro. *Clin. Oral Investig.* (2016).
39. Makeeva IM, Polyakova MA, Avdeenko OE, Paramonov YO, Kondrat'ev SA, Pilyagina AA: Effect of long term application of toothpaste Apadent Total Care Medical nano-hydroxyapatite. *Stomatologiya (Mosk)*, 95(4):34-36 (2016).
40. Zhang, M. *et al.* Biofilm layers affect the treatment outcomes of NaF and Nano-hydroxyapatite. *J. Dent. Res.* **94**, 602-607 (2015).
41. Nocerino, N. *et al.* Biological activity of lactoferrin-functionalized biomimetic hydroxyapatite nanocrystals. *Int. J. Nanomed.* **9**, 1175-1184 (2014).
42. Brambilla, E., Ionescu, A., Cazzaniga, G., Edefonti, V. & Gagliani, M. The influence of antibacterial toothpastes on in vitro *Streptococcus mutans* biofilm formation: a continuous culture study. *Am. J. Dent.* **27**, 160-166 (2014).

43. Hannig, C., Basche, S., Burghardt, T., Al-Ahmad, A. & Hannig, M. Influence of a mouthwash containing hydroxyapatite microclusters on bacterial adherence in situ. *Clin. Oral Investig.* **17**, 805-814 (2013).
44. Palmieri, C., Magi, G., Orsini, G., Putignano, A. & Facinelli, B. Antibiofilm activity of zinc-carbonate hydroxyapatite nanocrystals against *Streptococcus mutans* and mitis group *Streptococci*. *Curr. Microbiol.* **67**, 679-681 (2013).
45. Bikker, F. J., Cukkemane, N., Nazmi, K. & Veerman, E. C. Identification of the hydroxyapatite-binding domain of salivary agglutinin. *Eur. J. Oral Sci.* **121**, 7-12 (2013).
46. Lelli, M. *et al.* Different corrosive effects on hydroxyapatite nanocrystals and amine fluoride-based mouthwashes on dental titanium brackets: a comparative in vitro study. *Int. J. Nanomed.* **8**, 307-314 (2013).
47. Najibfard, K., Ramalingam, K., Chedjieu, I. & Amaechi, B. T. Remineralization of early caries by a nano-hydroxyapatite dentifrice. *J. Clin. Dent.* **22**, 139-143 (2011).
48. Arakawa, T. *et al.* Unique functions of hydroxyapatite with *mutans streptococci* adherence. *Quintessence Int.* **41**, e11-19 (2010).
49. Itthagarun, A., King, N. M. & Cheung, Y.-M. The effect of nano-hydroxyapatite toothpaste on artificial enamel carious lesion progression: an in-vitro pH-cycling study. *Hong Kong Dent. J.* **7**, 61-66 (2010).
50. Huang, S. B., Gao, S. S. & Yu, H. Y. Effect of nano-hydroxyapatite concentration on remineralization of initial enamel lesion in vitro. *Biomed. Mater.* **4**, 034104/034101-034104/034106 (2009).
51. Jeong, S. H., Hong, S. J., Choi, C. H. & Kim, B. I. Effect of new dentifrice containing nano-sized carbonated apatite on enamel remineralization. *Key Eng. Mater.* **330-332**, 291-294 (2007).
52. Lu, K., Meng, X., Zhang, J., Li, X. & Zhou, M. Inhibitory effect of synthetic nano-hydroxyapatite on dental caries. *Key Eng. Mater.* **336-338**, 1538-1541 (2007).
53. Lv, K., Zhang, J., Meng, X. & Li, X. Remineralization effect of the nano-HA toothpaste on artificial caries. *Key Eng. Mater.* **330-332**, 267-270 (2007).
54. Jeong, S. H. *et al.* Remineralization potential of new toothpaste containing nano-hydroxyapatite. *Key Eng. Mater.* **309-311**, 537-540 (2006).
55. Onuma, K., Yamagishi, K. & Oyane, A. Nucleation and growth of hydroxyapatite nanocrystals for nondestructive repair of early caries lesions. *J. Cryst. Growth* **282**, 199-207 (2005).
56. Kani, K. *et al.* Effect of apatite-containing dentifrices on dental caries in school children. *J. Dent. Health* **19**, 104-109 (1989).
57. Kani, T. *et al.* The effect of apatite-containing dentifrices on artificial caries lesions. *J. Dent. Health* **38**, 364-366 (1988).

C. Scientific papers: Enamel, erosion, whitening

58. Han, M., Li, Q.-L., Cao, Y., Fang, H., Xia, R., Zhang, Z.-H. In vivo remineralization of dentin using an agarose hydrogel biomimetic mineralization system. *Scientific Reports.* **7**:41955 (2017).
59. Nozari, A., Ajami, S., Rafiei, A. & Niazi, E. Impact of nano hydroxyapatite, nano silver fluoride and sodium fluoride varnish on primary teeth enamel remineralization: An in vitro Study. *J. Clin. Diagn. Res.* **11**, Zc97-zc100 (2017).
60. Poggio, C., Gulino, C., Mirando, M., Colombo, M. & Pietrocola, G. Protective effect of zinc-hydroxyapatite toothpastes on enamel erosion: An in vitro study. *J. Clin. Exp. Dent.* **9**, e118-e122 (2017).
61. Kensche, A. *et al.* Influence of calcium phosphate and apatite containing products on enamel erosion. *Scientific World J.* **2016**, 1-12 (2016).
62. Ajami, S., Pakshir, H. R., Babanouri, N. Impact of nanohydroxyapatite on enamel surface roughness and color change after orthodontic debonding. *Progress in Orthodontics*, 17:11 (2016).

63. Shaffiey, S. R. & Shaffiey, S. F. Surface enamel remineralization by biomimetic nano hydroxyapatite crystals and fluoride ions effects. *J. Ceram. Process. Res.* **17**, 109-112 (2016).
64. Colombo, M. *et al.* Protective effects of a zinc-hydroxyapatite toothpaste on enamel erosion: SEM study *Ann. Stomatol.* **7**, 38-45 (2016).
65. Min, J. H., Kwon, H. K. & Kim, B. I. Prevention of dental erosion of a sports drink by nano-sized hydroxyapatite in situ study. *Int. J. Paediatr. Dent.* **25**, 61-69 (2015).
66. Hill, R. G., Gillam, D. G. & Chen, X. The ability of a nano hydroxyapatite toothpaste and oral rinse containing fluoride to protect enamel during an acid challenge using ¹⁹F solid state NMR spectroscopy. *Mater. Lett.* **156**, 69-71 (2015).
67. Souza, B. M. *et al.* Effect of an experimental paste with hydroxyapatite nanoparticles and fluoride on dental demineralisation and remineralisation in situ. *Caries Res.* **49**, 499-507 (2015).
68. Porcelli, H. B., Maeda, F. A., Silva, B. R., Miranda, W. G. J. & Cardoso, P. E. Remineralizing agents: effects on acid-softened enamel. *Gen. Dent.* **63**, 73-76 (2015).
69. Besinis, A., Noort, R. v. & Martin, N. Remineralization potential of fully demineralized dentin infiltrated with silica and hydroxyapatite nanoparticles. *Dent. Mater.* **30**, 249-262 (2014).
70. Bonetti, G. A., Pazzi, E., Zanarini, M., Marchionni, S. & Checchi, L. The effect of zinc-carbonate hydroxyapatite versus fluoride on enamel surfaces after interproximal reduction. *Scanning* **36**, 356-361 (2014).
71. Lelli, M. *et al.* Remineralization and repair of enamel surface by biomimetic Zn-carbonate hydroxyapatite containing toothpaste: a comparative in vivo study. *Front. Physiol.* **5**, 333 (2014).
72. Mielczarek, A. & Michalik, J. The effect of nano-hydroxyapatite toothpaste on enamel surface remineralization. An in vitro study. *Am. J. Dent.* **27**, 287-290 (2014).
73. Poggio, C., Lombardini, M., Vigorelli, P., Colombo, M. & Chiesa, M. The role of different toothpastes on preventing dentin erosion: An SEM and AFM study. *Scanning* **36**, 301-310 (2014).
74. Carvalho, F. G. d. *et al.* In vitro effects of nano-hydroxyapatite paste on initial enamel carious lesions. *Pediatr. Dent.* **36**, 85-89 (2014).
75. Gjorgievska, E. S., Nicholson, J. W., Slipper, I. J. & Stevanovic, M. M. Remineralization of demineralized enamel by toothpastes: A scanning electron microscopy, energy dispersive x-ray analysis, and three-dimensional stereomicrographic study. *Microsc. Microanal.* **19**, 587-595 (2013).
76. Sadiasa, A. *et al.* Addition of hydroxyapatite to toothpaste and its effect to dentin remineralization. *Han'guk Chaelyo Hakhoechi* **23**, 168-176 (2013).
77. Jin, J., Xu, X., Lai, G. & Kunzelmann, K. H. Efficacy of tooth whitening with different calcium phosphate-based formulations. *Eur. J. Oral Sci.* **121**, 382-388 (2013).
78. Kutsch, V. K., Chaiyabutr, Y. & Milicich, G. Reconsidering remineralization strategies to include nanoparticle hydroxyapatite. *Compend. Contin. Educ. Dent.* **34**, 170-176 (2013).
79. Swarup, J. S. & Rao, A. Enamel surface remineralization: using synthetic nanohydroxyapatite. *Contemp. Clin. Dent.* **3**, 433-436 (2012).
80. Besinis, A., Noort, R. v. & Martin, N. Infiltration of demineralized dentin with silica and hydroxyapatite nanoparticles. *Dent. Mater.* **28**, 1012-1023 (2012).
81. Haghgoo, R., Abbasi, F. & Rezvani, M. B. Evaluation of the effect of nanohydroxyapatite on erosive lesions of the enamel of permanent teeth following exposure to soft beer in vitro. *Sci. Res. Essays* **6**, 5933-5936 (2011).
82. Huang, S., Gao, S., Cheng, L. & Yu, H. Remineralization potential of nano-hydroxyapatite on initial enamel lesions: An in vitro study. *Caries Res.* **45**, 460-468 (2011).

83. Li, L. et al. Bio-inspired enamel repair via Glu-directed assembly of apatite nanoparticles: an approach to biomaterials with optimal characteristics. *Adv. Mater.* **23**, 4695-4701 (2011).
84. Min, J. H., Kwon, H. K. & Kim, B. I. The addition of nano-sized hydroxyapatite to a sports drink to inhibit dental erosion: in vitro study using bovine enamel. *J. Dent.* **39**, 629-635 (2011).
85. Peetsch, A. & Epple, M. Characterization of the solid components of three desensitizing toothpastes and a mouth wash. *Materialwiss. Werkstofftech.* **42**, 131-135 (2011).
86. Tschoppe, P., Zandim, D. L., Martus, P. & Kielbassa, A. M. Enamel and dentine remineralization by nano-hydroxyapatite toothpastes. *J. Dent.* **39**, 430-437 (2011).
87. Poggio, C., Lombardini, M., Colombo, M. & Bianchi, S. Impact of two toothpastes on repairing enamel erosion produced by a soft drink: An AFM in vitro study. *J. Dent.* **38**, 868-874 (2010).
88. Roveri, N. et al. Surface enamel remineralization: biomimetic apatite nanocrystals and fluoride ions different effects. *J. Nanomater.* (2009).
89. Ryu, S.-C. et al. Regeneration of a micro-scratched tooth enamel layer by nanoscale hydroxyapatite solution. *Bull. Korean Chem. Soc.* **30**, 887-890 (2009).
90. Dabanoglu, A., Wood, C., Garcia-Godoy, F. & Kunzelmann, K. H. Whitening effect and morphological evaluation of hydroxyapatite materials. *Am. J. Dent.* **22**, 23-29 (2009).
91. Li, L. et al. Repair of enamel by using hydroxyapatite nanoparticles as the building blocks. *J. Mater. Chem.* **18**, 4079-4084 (2008).
92. Roveri, N. et al. Synthetic biomimetic carbonate-hydroxyapatite nanocrystals for enamel remineralization. *Adv. Mater. Res.* **47-50**, 821-824 (2008).
93. Park, Y.-D., Kim, J.-H. & Hwang, K.-S. Research about tooth whitening and bacteria sticking capability with using dentifrice including nano-hydroxyapatite, sodium metaphosphate. *Key Eng. Mater.* **330-332**, 283-286 (2007).
94. Kim, B. I. et al. Tooth whitening effect of toothpastes containing nano-hydroxyapatite. *Key Eng. Mater.* **309-311**, 541-544 (2006).
95. Yamagishi, K. et al. Materials chemistry: a synthetic enamel for rapid tooth repair. *Nature* **433**, 819 (2005).
96. Niwa, M. et al. Polishing and whitening properties of toothpaste containing hydroxyapatite. *J. Mater. Sci. Mater. Med.* **12**, 277-281 (2001).
97. Aoki, H. et al. Clinical study of teeth whitening properties of toothpastes containing hydroxyapatite. *Bioceram., Proc. Int. Symp. Ceram. Med.* **11**, 575-577 (1998).

D. Scientific papers: Sensitive teeth

98. Hiller, K.-A., Buchalla, W., Grillmeier, I., Neubauer, C. & Schmalz, G. In vitro effects of hydroxyapatite containing toothpastes on dentin permeability after multiple applications and ageing. *Sci. Rep.* **8**, 4888 (2018).
99. Jena, A., Kala, S. & Shashirekha, G. Comparing the effectiveness of four desensitizing toothpastes on dentinal tubule occlusion: A scanning electron microscope analysis. *J. Conserv. Dent.* **20**, 269-272 (2017).
100. Vano, M., Derchi, G., Barone, A. & Pinna, R. Reducing dentine hypersensitivity with nano-hydroxyapatite toothpaste: a double-blind randomized controlled trial. *Clin. Oral Invest.*, doi:10.1007/s00784-017-2113-3 (2017).
101. Oliveira, D. W. D. et al. Effectiveness of three desensitizing dentifrices on cervical dentin hypersensitivity: A pilot clinical trial. *J. Int. Acad. Periodontol.* **18**, 57-65 (2016).
102. Wang, L. et al. Treatment of dentin hypersensitivity using nano-hydroxyapatite pastes: A randomized three-month clinical trial. *Oper. Dent.* (2016).

103. Kulal, R., Jayanti, I., Sambashivaiah, S. & Bilchodmath, S. An In-vitro comparison of nano hydroxyapatite, novamin and proargin desensitizing toothpastes - a SEM study. *J. Clin. Diagn. Res.* 10, Zc51-zc54 (2016).
104. Amaechi, B. T., Mathews, S. M., Ramalingam, K. & Mensinkai, P. K. Evaluation of nanohydroxyapatite-containing toothpaste for occluding dentin tubules. *Am. J. Dent.* 28, 33-39 (2015).
105. Farooq, I., I. A. Moheet, I. A. & E. AlShwaimi, E. In vitro dentin tubule occlusion and remineralization competence of various toothpastes. *Arch. Oral Biol.* 60, 1246-1253 (2015).
106. Genovesi, A. M. et al. In vitro comparison of three desensitizing prophylaxis pastes: a morphological analysis. *J. Oral Hyg. Health* 3, 1000186 (2015).
107. Gopinath, M. M., Kumar, E. S., John, J., Nagappan, N. & Prabhu, S. Evaluation of dentifrice containing nano-hydroxyapatite for dentinal hypersensitivity: A randomized controlled trial. *J. Int. Oral Health.* 7, 118-122 (2015).
108. Vano, M., Derchi, G., Barone, A., Genovesi, A. & Covani, U. Tooth bleaching with hydrogen peroxide and nano-hydroxyapatite: a 9-month follow-up randomized clinical trial. *Int. J. Dent. Hyg.* 13, 301-307 (2015).
109. Hill, R. G., Chen, X. & Gillam, D. G. In vitro ability of a novel nanohydroxyapatite oral rinse to occlude dentine tubules. *Int. J. Dent.* 2015, 153284 (2015).
110. Arnold, W. H., Prange, M. & Naumova, E. A. Effectiveness of various toothpastes on dentine tubule occlusion. *J. Dent.* 43, 440-449 (2015).
111. Low, B. S., Allen, E. P. & E. D. Kontogiorgos. Reduction in dental hypersensitivity with nano-hydroxyapatite, potassium nitrate, sodium monofluorophosphate and antioxidants. *Open Dent. J.*, 92-97 (2015).
112. Vano, M., Derch, G., Barone, A. & Covani, U. Effectiveness of nano- hydroxyapatite toothpaste in reducing dentin hypersensitivity: a double-blind randomized controlled trial. *Quintessence Int.* 45, 703-711 (2014).
113. Orsini, G. et al. A 3-day randomized clinical trial to investigate the desensitizing properties of three dentifrices. *J. Periodontol.* 84, 65-73 (2013).
114. Browning, W. D., Cho, S. D. & Deschepper, E. J. Effect of a nano- hydroxyapatite paste on bleaching-related tooth sensitivity. *J. Esthet. Restor. Dent.* 24, 268-276 (2012).
115. Yuan, P. et al. Effects of dentifrice containing hydroxyapatite on dentinal tubule occlusion and aqueous hexavalent chromium cations sorption: a preliminary study. *PloS one* 7, e45283 (2012).
116. Orsini, G. et al. A double-blind randomized-controlled trial comparing the desensitizing efficacy of a new dentifrice containing carbonate/hydroxyapatite nanocrystals and a sodium fluoride/potassium nitrate dentifrice. *J. Clin. Periodontol.* 37, 510-517 (2010).

117. Shetty, S., Kohad, R. & Yeltiwar, R. Hydroxyapatite as an in-office agent for tooth hypersensitivity: a clinical and scanning electron microscopic study. *J. Periodontol.* 81, 1781-1789 (2010).
118. Kim, S.-H. et al. The clinical effects of a hydroxyapatite containing toothpaste for dentine hypersensitivity. *J. Korean Acad. Periodontol.* 39, 87-94 (2009).
119. Lee, S. Y., Kwon, H. K. & Kim, B. I. Effect of dentinal tubule occlusion by dentifrice containing nano-carbonate apatite. *J. Oral Rehabil.* 35, 847-853 (2008).
120. Rimondini, L. et al. The remineralizing effect of carbonate-hydroxyapatite nanocrystals on dentine. *Mater. Sci. Forum* 539-543, 602-605 (2007).
121. Hüttemann, R. W. & Dönges, H. Untersuchungen zur Therapie überempfindlicher Zahnhälse mit Hydroxylapatit. *Dtsch. Zahnärztl. Z.* 42, 486-488 (1987).