COMPARATIVE EFFECT OF A CANDIDATE MODIFIED RISK TOBACCO PRODUCT AEROSOL AND CIGARETTE SMOKE ON COLOR STABILITY OF ENAMEL, DENTIN AND DENTAL COMPOSITE RESINS

Filippo Zanetti[1], Xiaoyi Zhao[2,3], Shoaib Majeed[1], Hans Malmstrom[2], Manuel C. Peitsch[1], Yanfang Ren[2], Julia Hoeng[1]

[1] PMI R&D, Philip Morris Products S.A., Neuchâtel, Switzerland (part of Philip Morris International group of companies)
[2] University of Rochester Eastman Institute for Oral Health, Rochester, New York
[3] Peking University School of Stomatology, Peking, China

#181

Introduction and Objectives

Introduction. Cigarette smoke (CS) has been recognized as one of the factors causing stain and discoloration of teeth and restorative composite resin **[1]**. CS increases water sorption and solubility of composite resins **[2]**, which may lead to deposition of metal ions into the resin matrix **[3]** and increase their discoloration **[4]**. Smoking could also decrease the luminosity and increase the resin surface roughness **[5]** and affect the bonding strength of dental composite resins to dentin, which may compromise the long-term outcomes of the restorations **[6]**. CS affects also the surface properties, like microhardness, of dental hard tissues and restorations and causes discoloration of teeth **[7]**. The severity of smoke-related dental discoloration is largely dependent on the quantity of tar generated during the combustion of tobacco at very high temperatures. Modified risk tobacco products (MRTP) are a promising alternative to continued smoking for people unwilling to quit. Some of these products, such as the Tobacco Heating System (THS) 2.2, a candidate MRTP, heats tobacco instead of burning it and does not produce "tar" as that term is commonly defined and understood (i.e., the particulate residue from CS when a cigarette is burned). Accordingly, THS2.2 carries the potential to minimize the risk of tooth and dental composite discoloration **[8]**.

Objectives. In this study, we investigated, for the first time, the effects of the aerosol generated by THS2.2 on color stability and surface roughness of premolar human teeth and composite resins, compared with that generated by CS.

Methods

Composite resin discs. 60 discs, 6.0 mm in diameter and 1.5 mm thick, were prepared as previously described **[9]** from the following composite resins:

- Microfilled composite resin: Durafill® VS (DVS) (Heraeus-Kulzer GmbH, Hanau, Germany)
- Microhybrid composite resin: Tetric EvoCeram® BulkFill (TEC) (Ivoclar-Vivadent, Schaan, Liechtenstein)
- Nanofilled universal composite resin: Filtek™ Supreme Ultra (FSU) (3M ESPE, St. Paul, MN, USA)

Human premolar teeth. Twenty-two human premolars extracted for orthodontic reasons were collected fresh from oral surgery clinics at University of Rochester Eastman Institute for Oral Health and sterilized with ethylene oxide overnight before use. Teeth collection followed University of Rochester IRB guidelines. Class V cervical cavities were prepared on extracted premolars and the cavities restored with the FSU universal composite resin. Root surface apical to the cementum-enamel junction were polished to expose an area (3x5mm) of the underlying dentin.

Color assessment. Color of premolar teeth was assessed in the Commission Internationale de l'Eclairage L*a*b* (CIE Lab) color space using an Olympus CrystalEye® dental spectrophotometer (Olympus, Tokyo, Japan).

Roughness assessment. Surface roughness of the composite resin discs was assessed by 3D scanning microscopy (InfiniteFocus G4, Alicona Imaging GmbH, Graz, Austria).

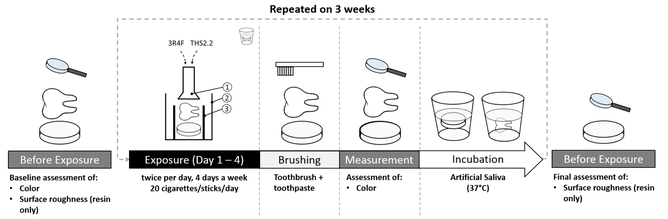


Figure 1. Study design.

The color of human premolar teeth and composite resins was assessed in the CIE Lab space to establish baseline values. Surface roughness was measured only for composite resins. After exposure in the Vitrocell® 24/48 system (Vitrocell® System GmbH, Waldkirch, Germany) to undiluted CS from reference cigarettes 3R4F (University of Kentucky, Kentucky Tobacco Research and Development Center) and THS2.2 (Philip Morris International) aerosol from 20 cigarettes/sticks per day for 4 days, samples were brushed with toothpaste and measured for color. The exposures and measurements were repeated through 3-weeks. Surface roughness was measured at the end of the 3 weeks of exposure. 1, aerosol inlet; 2, Vitrocell plate well; 3, Vitrocell insert.

Results

Effects of 3R4F CS and THS2.2 aerosol exposures on surface roughness of composite resin discs

Figure 2. At the baseline, TEC had a greater surface roughness than DVS and FSU (0.18 vs. 0.08 and 0.09, respectively). Exposure to either 3R4F CS or THS2.2 aerosol did not affect the surface roughness of the composite resins used in the present study. Surface roughness was significantly associated with discoloration (ΔE) in the 3R4F group (Pearson's r=0.54, p<0.01) but not in the THS2.2 group (Pearson's r=0.36, p>0.05) (data not shown) **[10]**.

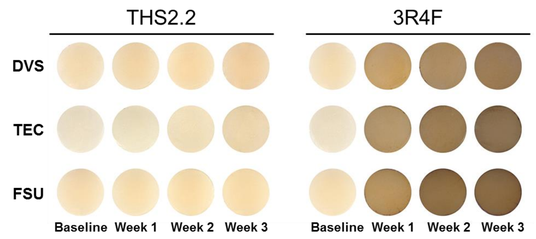
	DVS		TEC		FSU	
	Baseline	Final	Baseline	Final	Baseline	Final
3R4F	0.08 ±0.02	0.07 ±0.03	0.18 ±0.07	0.15 ±0.03	0.09 ±0.02	0.09 ±0.01
THS2.2	0.09 ±0.02	0.08 ±0.02	0.15 ±0.08	0.14 ±0.04	0.10 ±0.01	0.10 ±0.01
p*	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Surface roughness values (Mean±SD) of composite discs before and after three weeks of exposure to 3R4F CS and THS2.2 aerosol. *Student's *t*-tests, THS2.2 vs. 3R4F. N = 10 per group.

Results

Effects of 3R4F CS and THS2.2 aerosol exposures on color of dental composite resins

Figure 3. There were significant differences in ΔE , the spectrophotometric score calculated based on the CIE LAB values, between THS2.2 and 3R4F groups for each composite resin at all timepoints. The THS2.2 aerosol affected the composite resins with a different pattern from 3R4F CS. While 3R4F CS caused more discoloration in TEC (ΔE =30.4) and FSU (ΔE =28.0) than in DVS (ΔE =23.0), the effects of the THS2.2 aerosol were more pronounced in DVS (ΔE =4.0) and TEC (ΔE =5.3) than in FSU (ΔE =2.6) **[10]**.

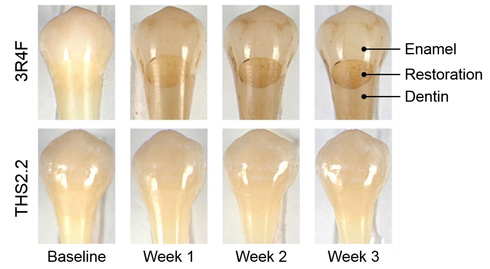


	DVS			TEC			FSU		
	Week1	Week2	Week3	Week1	Week2	Week3	Week1	Week2	Week3
3R4F	17.0 ±1.4	20.7 ±1.4	23.0 ±1.2	20.6 ±1.8	26.7 ±2.0	30.4 ±1.4	20.1 ±1.7	26.2 ±2.7	28.0 ±2.5
THS2.2	2.1 ±0.8	3.3 ±0.9	4.0 ±0.6	1.6 ±1.0	3.6 ±0.9	5.3 ±1.5	0.9 ±0.6	1.9 ±0.6	2.6 ±0.5
p*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

ΔE values (Mean±SD) of composite discs after 3 weeks of exposure to 3R4F CS and THS2.2 aerosol. *Student's *t*-tests, THS2.2 vs. 3R4F. N = 10 per group.

Effects of 3R4F CS and THS2.2 aerosol exposures on color of human premolar teeth

Figure 4. *ΔE* increased with time in enamel and dentin in both groups, but to a far lesser extent in the THS2.2 (*ΔE* 1.2 to 3.1) than in the 3R4F (*ΔE* 5.2 to 21.3) group. THS2.2 aerosol affected enamel (*ΔE* 1.2 to 2.8) and dentin (*ΔE* 1.2 to 3.1) to the same extent. Class V composite resin (FSU) restorations on the premolar teeth were affected to the same extent as enamel (*ΔE* 1.1 to 3.0) and dentin in the THS2.2 group but not in the 3R4F group, where the composite resin was affected to a much greater extent (*ΔE* 12.5 to 25.6) than enamel and dentin.



	Enamel			Dentin			Restoration		
	Week1	Week2	Week3	Week1	Week2	Week3	Week1	Week2	Week3
3R4F	5.2 ±2.2	7.1 ±2.3	8.8 ±2.6	13.9 ±3.0	18.2 ±3.9	21.3 ±4.4	12.5 ±2.6	19.0 ±4.3	25.6 ±3.8
THS2.2	1.2 ±0.8	2.0 ±1.0	2.8 ±1.2	1.2 ±0.6	2.4 ±0.7	3.1 ±0.8	1.1 ±0.9	1.9 ±0.8	3.0 ±1.0
p*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

ΔE values (mean ± SD) of enamel, dentin, and composite resin after three-week exposure to 3R4F CS and THS2.2 aerosol. *Student's *t*-tests, THS2.2 vs. 3R4F. N = 11 per group.

Conclusions

- THS2.2 aerosol caused six- to ten-fold less discoloration of composite resin materials than 3R4F CS as measured by *ΔE* after 1 to 3 weeks of exposure.
- The effects of THS2.2 aerosol on dental tissue discoloration were four- to seven-fold lower than CS and were not clinically significant (ΔE <3.3) after three weeks of exposure.
- CS (but not THS2.2 aerosol) caused color mismatch between enamel and composite resin restorations, which compromises the aesthetic outcome of restorative treatment.
- Surface roughness was not altered by either 3R4F CS or THS2.2 aerosol, after 3 weeks of exposure.
- Brushing was limited to once at the end of each experimental week. This design was employed to maximize the potential staining of the dental materials/tissues by CS/THS2.2 aerosol in a limited time frame.
- In summary, aerosol derived from heating tobacco causes significantly lower 1) discoloration of enamel, 2) dentin and composite-resin restoration, and 3) color mismatch between dental hard tissues and restoration than CS. Reducing or eliminating the deposits derived from tobacco combustion may minimize the impact on tooth and composite resin restoration color stability.

PMI SCIENCE
PHILIP MORRIS INTERNATIONAL

References

[1] C.N. Raptis, J.M. Powers, P.L. Fan, et al., Staining of composite resins by cigarette smoke, J Oral Rehabil 9(4) (1982) 367-71.
[2] P. Mathias, S.R. Santos, T.R. Aguiar, et al., Cigarette smoke: effects on water sorption and solubility of restorative dental composites, Gen Dent 62(2) (2014) 54-7.
[3] C.Y. Takeuchi, A.M. Correa-Afonso, H. Pedrazzi, et al., Deposition of lead and cadmium released by cigarette smoke in dental structures and resin composite, Microsc Res Tech 74(3) (2011) 287-91.
[4] P. Mathias, L. Costa, L.O. Saraiva, et al., Morphologic texture characterization allied to cigarette smoke increase pigmentation in composite resin restorations, J Esthet Restor Dent 22(4) (2010) 252-9.
[5] C.C. Alandia-Roman, D.R. Cruvinel, A.B. Sousa, et al., Effect of cigarette smoke on color stability and surface roughness of dental composites, J Dent 41 Suppl 3 (2013) e73-9.
[6] J.D. Theobaldo, A. Catelan, U. Rodrigues-Filho, et al., Effect of Cigarette Smoke on Resin Composite Bond Strength to Enamel and Dentin Using Different Adhesive Systems, Oper Dent (2015).
[7] C.E. dos Santos Bertold, D. de Azevedo Miranda, E.J. Souza-Junior, et al., Surface hardness and color change of dental enamel exposed to cigarette smoke, International Journal of Dental Clinics 3(4) (2011).
[8] M.R. Smith, B. Clark, F. Lüdicke, et al., Evaluation of the Tobacco Heating System 2.2. Part 1: Description of the system and the scientific assessment program, Regul Toxicol Pharmacol 81 () S17-26.
[9] Y.F. Ren, L. Feng, D. Serban, et al., Effects of common beverage colorants on color stability of dental composite resins: the utility of a thermocycling stain challenge model in vitro, Journal of Dentistry 40 Suppl 1 (2012) e48-56.
[10] X. Zhao, F. Zanetti, S. Majeed, et al., Effects of cigarette smoking on color stability of dental resin composites. Am J Dent 30(6) (2017) 16-322.

Competing Financial Interest

F.Z., S.M., M.P., and J.H. are employees of Philip Morris International. Philip Morris International is the sole source of funding and sponsor of the research described in this poster.