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Journal of Contemporary Orthodontics

Journal homepage: https://www.jco-ios.org/

Original Research Article

Evaluation of leaching from orthodontic polymers using a simplified chemical method - An in vitro study

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ARTICLE INFO

Article history:
Received 08-08-2024
Accepted 02-11-2024
Available online 08-02-2025

Keywords:
BisphenolA
Cytotoxicity
Composite Resins
Potassium Permanganate
Orthodontic Retainers

ABSTRACT

Aims and Objectives: This research assessed and contrasted the leaking of possibly hazardous polymers that leach after commonly used orthodontic materials.
Material and Methods: The study assessed three groups Adhesives, retainers, and elastomeric chains ligating rings. A diagnostic solution was arranged with 1.6 mg potassium permanganate (ACS reagent grade, 99%) added to 1L of concentrated water. The study included three trials. In trial 1, samples were immersed in 5 ml of potassium permanganate solution. In trial 2, the solution was adulterated with distilled water in a 1:3 ratio. In trial 3, acid was supplementary to the solvent to lower the PH to 1, and samples from all groups were immersed.
A digital camera was used to snap samples for color changes over time.
Results: Each fresh sample was tested over ten days. The faster discolouration indicated greater leaching. Results were anatomized using SPSS interpretation 11 and the Chi-square test, with a P-value of lower than 0.05 measured statistically notable. Rely-a-bond(no- blend) tenacious percolated significantly further polymer than Transbond XT adhesive after 8 hours. Self-cure acrylic, Bioplast sheets, and elastomeric chains from Ortho- organizer and Ormco also percolated polymers.
Conclusion: The " Do- it- yourself " tests effectively indicated polymer filtering, abetting manufacturers in optimizing products and clinicians in choosing safer options. The short- term threat of estrogenic goods from BPA- grounded resins is inconsequential.

1. Introduction

Polymers serve as the foundational substance for numerous plastics and bias used in orthodontics, similar as adhesives, retainers, elastomeric chains, and elastic ligation rings. These accoutrements are frequently in direct contact with mortal soft tissues for extended ages. Unlike pharmaceuticals, which are subject to well-defined government safety regulations, polymers are fairly new to the field, and specific regulations for them haven't been easily established. Accordingly, manufacturers constantly don't expose the constituents or product styles used for these accoutrements, and numerous orthodontic journals accept papers that source marketable names without furnishing detailed scientific information.

Bisphenol- A (BPA) is an artificial biochemical generally used in manufacturing polycarbonate plastics and other products. According to research exhibited lately BPA can

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https://doi.org/10.18231/j.jco.2025.016

strain from certain products, similar as white dental fillings and sealants. Indeed at low situations, BPA has been set up to produce cellular influence by mimicking the action of the female hormone estrogen. As a result, BPA is classified as a" hormone disruptor" or" endocrine disruptor" because it can intrude with the body's chemical messenger system.

In the history, tests have been organised to spot the presence and quantify the dangerous by- products released from certain orthodontic accoutrements. still, these studies are frequently precious, bear sophisticated equipment, and involve complex procedures. thus, there's a pressing need to develop a modest yet efficient test to descry and determine the dangerous derivatives leaked after using general orthodontic accoutrements. [1–7]

2. Materials and Methods

This study concentrated on generally used orthodontic accoutrements, including adhesives(e.g., Transbond XT), retainers, elastomeric chains, and elastic ligating rings.

Formulation of diagnostic solutions: A diagnostic solution was prepared by dissolving 1.6 mg of potassium permanganate(ACS reagent grade, 99%) in 1L of concentrated water. After thorough mixing, the solution deposited in a locked flask for no less than 60 minutes before use. The solution also transferred into 10 ml limited test tubes, each containing one of the polymeric products being tested, similar as adhesives, retainers, elastomeric chains, and elastic ligating rings.

The response progressed in 2 customs, reliant on the PH of the solution.

1. Neutral ground: In a neutral ground, the purple-coloured permanganate(KMnO4) was condensed to manganese dioxide(MnO2) and manganese(III) oxide(Mn2O3), performing in a brownish-yellow shade in the result.
2. Acidic ground: To produce an acidic ground, a few drops of phosphoric or hydrochloric acid were added to the solution, lowering the pH to roughly 1 – 2. This further reduced the manganese to colourless salts, causing the result to become clear.

The color changes of the diagnostic solution were demonstrated using a digital camera.

2.1. Method

The trial was carried out in the Dept. of Bio-chemistry, Central college, Bangalore University, Bangalore.

The analysis then isolated into three other trials.

2.2. Trial I

Once the formulation of the diagnostic solution was done, in resemblant.

Group I samples then equipped for experimenting, i.e., Transbond- XT light cure was spread on a Teflon surface and cured according to manufacturer recommendations. Instantaneously Rely- a bond was cured chemically, after curing, the foils were chilled and condensed to insignificant elements by means of coffee grinder.

Group II samples i.e., self-cure acrylic retainers and Bio-Plast sheets were also condensed to small elements using a similar system.

As group III samples i.e., elastomeric chains and elastic ligating rings are rubber like, grinding won't be effective in fine- enough elements. Due to the resiliency of the rubber-like material, grinding was not affective in fine enough to expose a large face area to the disclosing solution.

As heating would alter the composition, a technique used to disintegrate tissue in biology is used. The samples were first cooled by absorption in pristine sword tea- baskets into liquid nitrogen and also incontinently crushed with a hammer that yielded fine enough elements.

Then entire the tasters of all groups of 1gm each counted and submerged in 5 ml of KMnO4 diagnostic solution taken in 10CC limited flask and they are numbered from zero to eight which contain different testing samples.

1. Control
2. Transbond- XT(light cure)
3. Rely-a-bond(no mix0
4. tone cure tempera
5. Bioplast wastes
6. Elastomeric- chain (Ortho- organizers)
7. Elastomeric- chain (Ormco)
8. Elastic ligating rings –(Ormco)
9. Elastic ligating rings –(3M)

Using digital camera, the experiments were recorded for color changes throughout distinctive time intervals.

1. (a) At 5 min
   (b) At 30 min
   (c) At 8 hrs
   (d) At 24 hrs

2.3. Trial II

The KMnO4 diagnostic solvent then adulterated using concentrated water to a rate of 1:3 and the testers were immersed in the diagnostic solution and observed for color changes as in trial I.

2.4. Trial III

To KMnO4 diagnostic solution, an acid is supplemented to reduce the PH to one and the those testers will be diluted in

the performing solution and pictures were clicked for color changes as in trial I.

All the testers will be subordinated to test on 10 other days, the results charted and statistically estimated considering that the quickly the abrasion time, the greater the quantum of percolated product present.

3. Results

This study examines eight common polymeric products used in the Department, divided into three groups –

1. Group I: (Bonds)(a) Transbond- XT,(b) Calculate-a-bond(no blend) –
2. Group II: (Retainers) (a) tonecure tempera, (b) Bioplast wastes –
3. Group III: Elastomeric Chains (a) Ortho- organizer, (b) Ormco

Elastic Ligating Rings (a) Ormco, (b) 3M

1. Trial I: One gram of each sample was immersed in 5 ml of neutral potassium permanganate solution. Color changes were seen and anatomized at intervals of 5 and 30 minutes, 8 and 24 hours.
2. Trial II: The KMnO4 solution was adulterated with concentrated water at a 1:3 rate, and samples were tested as in trial I.
3. Trial III: The potassium permanganate solution was acidified with phosphoric acid to reduce PH to 1. Samples were also anatomized for color changes as in trial I.

Each sample was tested over ten different days. Results were statistically anatomized using SPSS interpretation 11 and the Chi-square test, with a p- value less than 0.05 considered statistically significant. Faster the colour changes indicated a greater quantum of percolated product.

3.1. Comparison analysis of polymer filtering from two adhesives

Transbond- XT and Rely-a-bond were compared for polymer filtering at 5 minutes, at 30 minutes, at 8 hours and at 24 hours. It was set up that Rely-a-bond(no- blend) chemically cured adhesive had percolated statistically significant quantum of polymer than Transbond-XT adhesive after 8 hours(Table 1).

4. Comparison Analysis of Polymer Filtering from Two Retainers

Two retainer materials namely Self cure acrylic and Bioplast sheets were compared for polymer leaching at 5 minutes, at 30 minutes, at 8 hours and at 24 hours. It was found that both retainers had leached polymer. When statistically evaluated for polymer leaching, there is no statistically major difference among 2 retainers(Table 2).

5. Comparison Analysis of Polymer Filtering from Two Elastomeric Chains and Elastic Modules

Two Elastomeric chains manufactured by Ortho-organizer, Ormco and Two elastic modules manufactured by Ormco and 3M were compared for polymer leaching at 5 minutes, at 30 minutes, at 8 hours and at 24 hours. It was found that both Elastomeric chains and elastic modules had leached the polymer. Ortho-organizer Elastomeric chains had percolated slightly higher amount of polymer than Ormco Elastomeric chain as evidenced by color changes. However when statistically evaluated, there is no variation between the two as evidenced P value which is more than 0.05 in all the time intervals. Ormco elastic modules had percolated statistically higher quantity of polymer than 3M elastic modules as evidenced by colour change in all the time intervals(Table 3).

6. Discussion

The orthodontic accoutrements in use now are composed of various constituents, numerous of which may be dangerous to the human body. It has been emphasized that the composites used for medical and dental purpose, involving tissue contact, must be biocompatible to help avoiding adverse tissue responses. Tests have been conducted in the history, like High Performance Liquid Chromatography(HPLC) and Spectrophotometry to descry the presence of dangerous derivatives percolated from particular orthodontic accoutrements. The most important downsides of above experiments are that they are high-priced, largely complicated and bear certain equipment. consequently, there's a necessity to invent an easy but efficient experiment to descry and determine the number of dangerous polymers percolated from the usually used orthodontic accoutrements.

Disagreement bounds this topic since it's uncertain in what way BPA or BPA- DM is percolated to the oral cavity and what quantity is enough to affect mortal health. A clinical study by Olea et al.[1,2] in 1996 mentioned that BPA was gathered in slaver in next hour of sealant application, convincing the researchers to decide that sealant procedure manages to xenoestrogen exposure in minors. Current researches have shown that Bisphenol-A- DM have to confined for practice in resin-based compounds since its potent estrogenic effect and because of high levels found in the body, but still, the consequence of BPA is negligible. farther exploration should be conducted in vivo to show the chemical exertion of these composites and their effect on human development.

This study involved a easy yet affordable " do- it-yourself "(DIY) test where polymer testers were immersed in a KMnO4 solution, then the colour variations were witnessed and evaluated with controls.

As this do-it-yourself test totally depends on observation, it could not measure the accurate amount of polymer leached. But it could help the clinician in screening of orthodontic polymers, so that the clinician can choose the least harmful polymer by choosing the ones that leach the least.

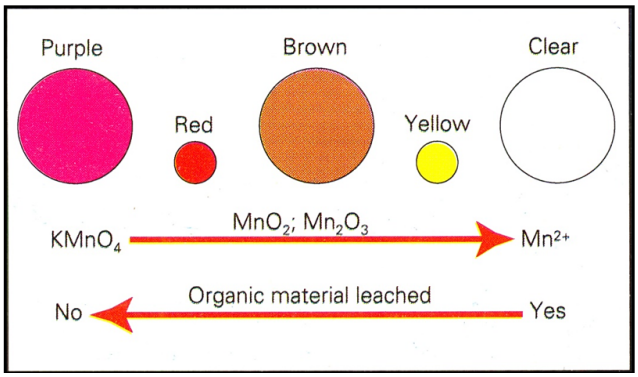

Figure 1: Photograph showing basic chemical reaction

In a neutral ground, the purple Mn7 ions of potassium permanganate are reduced to manganese ions Mn2 and Mn3, that give the solution of yellowish- brown colour. In an acidic ground, manganese is converted to a almost colourless salts(Mn2). still, to the yellowish– brown acidic solution containing Mn oxides, further reducing agent(polymer) is supplemented, the colour changed to transparent as manganese is further downgraded to salt(Figure 1).

Thus it was considered that above simple DIY experiment can be carried out to measure the quantum of polymer percolated relying upon the color variations from purple to brown and eventually to clear in the polymer testers submerged in a solution of KMnO4. All the polymers tested demonstrated leaching, but to varying degrees. Though the time taken for color change varied in samples, all of them showed discolouration indicating that some oxido- reduction has taken place.

The outcome follows somewhat contrarily in a neutral, diluted and acidic grounds. In experiment - I (neutral ground), the reaction was slow and significant discoloration of many samples was evident after 24hours. In neutral environment when potassium permanganate solution was observed for color changes at 5 and 30 minutes, at 8 and 24 hours, it was seen that Transbond- XT light cure adhesive (sample-1) had percolated considerably smaller amount than Rely-a-bond no mix adhesive (sample-2). When both adhesives were compared for polymer leaching, statistically sample-2 has leached significantly more amount than sample-1. This is because sample-2 adhesive contains every essential drawback of the chemical curing process. Amalgamation of the paste and liquid components of the chemically cured adhesive (sample-2) develops vacuums and persuades air trap in the greater part of material by enhancing the penetrability and polymerization inhibition, which escalates the quantity of unreacted polymer in the adhesive that further enhances the ability of polymer leaking.

In Group II testers, Self-cured acrylic retainer (Sample-3) percolated higher than Bio-plast sheets (Sample-4). The reason for this is that sample-3 is chemically cured; extent of polymerization is incomplete. And there is a higher volume of unreacted polymer is seen. After 24 hours, when noticed for colour change sample-4 similarly percolated evidently as proved by colour change. There was no statistically evident amount leaching was seen when both retainers evaluated.

In this study two brands of elastomeric chains and two brands of elastomeric ligating rings were tested. In elastomeric chains, Ortho-organizers elastomeric chains (Sample-5) had leached more amount than Ormco elastomeric chains (Sample-6). After 24 hours, when samples were observed for discoloration, both Elastomeric chains leached polymer. When statistically evaluated, for polymer percolation and no significant variation among two was found, but sample-5 leached slightly higher amount polymer than sample-6 as evidenced by the color change.

In between Elastomeric ligating rings, Ormco Elastomeric ligating rings (sample-7) percolated higher level of polymer than 3M Elastomeric ligating rings (sample-8). After 24hours when samples of Elastomeric ligating rings were observed for discoloration sample-7 percolated significantly more quantity of polymer than sample-8.

In this study, sample-7 was seen percolating higher extent of polymer than sample-8. The elastomeric chains have the added drawback of not being active in the oral environment. Huget et al.[8] mentioned that water acts as a plasticizer by weakening inter- molecular forces in the polyurethanes, piloting to chemical degradation. Chromatographic analysis has shown increased leaching from elastomeric modules submerged in water.[9–13]

In neutral and diluted grounds, the outcome is gradual and colour change was more hard to evaluate due to the appended flecks of manganese oxides (MnO_4 and Mn_2O_3), thus in experiment-III an acidic ground was chosen. In acidic environment, the process was much faster and shades varied between transparent and purple and significant color change was observed within 30minutes, reducing the testing time by few hours.

Given the parameters of this study, the subsequent conclusions may be inferred.:

1. (a) Percolation of quantity of polymer is notably more in sample-2 than sample-1.
   (b) No statistically appreciable disparity was detected in the amount of percolated polymer between sample-3 and sample-4.
   (c) No statistically appreciable disparity was detected in the amount of percolated polymer between

Table 1: Comparison analysis of polymer leaching from two adhesives

Group 1 In neutral potassium permanganate Time		**Purple**	**Red**	**Brown**	**Yellow**	**Clear**	**Total**
After 5 minutes	Transbond -XT (N) Percentage	8 80%	2 20%				10 100%
	Rely-a-bond (N) Percentage	6 60%	4 40%				10 100%
After 30 minutes	Transbond -XT (N) Percentage	7 70%	2 20%	1 10%			10 100%
	Rely-a-bond (N) Percentage	5 50%	2 20%		3 30%		10 100%
After 8 hours	Transbond -XT (N) Percentage	5 50%	2 20%	2 20%	1 10%		10 100%
	Rely-a-bond (N) Percentage		2 20%	3 30%	2 20%	3 30%	10 100%
After 24 hours	Transbond -XT (N) Percentage	4 40%	1 10%	3 30%	2 20%		10 100%
	Rely-a-bond (N) Percentage			1 10%	3 30%	6 60%	10 100%
Group 1 In Diluted Potassium permanganate							
After 8 hours	Transbond XT (N) Percentage	2 20%	2 20%	2 20%	4 40%		10 100%
	Rely-a-bond (N) Percentage			2 20%	2 20%	6 60%	10 100%
After 24 hours	Transbond -XT (N) Percentage		3 30%	4 40%	3 30%		10 100%
	Rely-a-bond (N) Percentage				3 30%	7 70%	10 100%
Group 1 In Acidified Potassium permanganate							
After 8 hours	Transbond -XT (N) Percentage		2 20%	2 20%	3 30%	3 30%	10 100%
	Relay-a-bond (N) Percentage					10 100%	10 100%
After 24 hours	Transbond -XT (N) Percentage			4 40%	3 30%	3 30%	10 100%
	Relay-a-bond (N) Percentage					10 100%	10 100%

Table 2: Group 2 In neutral potassium permanganate

Time		**Purple**	**Red**	**Brown**	**Yellow**	**Clear**	**Total**
After 5 minutes	Self cure acrylic (N) Percentage	9 90%	110%				10 100%
	Bioplast sheets (N) Percentage	10 100%					10 100%
After 30 minutes	Self cure acrylic (N) Percentage	5 50%	220%	2 20%	110%		10 100%
	Bioplast sheets (N) Percentage	8 80%	220%				10 100%
After 8 hours	Self cure acrylic (N) Percentage	3 30%	110%	2 20%	4 40%	10 100%	10 100%
	Bioplast sheets (N) Percentage	6 60%	110%	3 30%		10 100%	10 100%
After 24 hours	Self cure acrylic(N) Percentage				1 10%	9 90%	10 100%
	Bioplast sheets(N) Percentage			2 20%	3 30%	5 50%	10 100%

sample-5 and sample-6.

(d) In case of Elastomeric ligating rings, sample-7 is seen percolating statistically higher quantity of polymer than sample-8 except after 30 minutes in neutral potassium permanganate.

The sophisticated International Standard Organization (ISO) technique to distinguish organic adulterations is so delicate that it is presently used to evaluate tap water. Though, the easy technique showed in this study uses DIY test to specify the point to which a polymer percolates oxidizable organic matter.[14–17] By representing the amount of percolation, the technique permits manufacturers to assist in their polymer-containing products and the clinician to select the less damaging ones.[18–20]

With the sudden upsurge in innovative dental materials, it appears that this moment is the time to specify improved guiding principles for their testing and use. Possibly an easy laboratory technique as executed in this study will aid as a screening process for more extensive, precise, and costly

Table 3: Group 3 In diluted potassium permanganate

Time		**Purple**	**Red**	**Brown**	**Yellow**	**Clear**	**Total**
	Ortho-organizer (N)					10 100%	10 100%
After 24	Percentage						
Hours	Ormco (N) Percentage			1 10%	3 30%	6 60%	10 100%
	Ormco elastic modules (N)					10 100%	10 100%
	Percentage						
	3M elastic modules (N)	4 40%	1 10%	4 40%	1 10%		10 100%
	Percentage						
Group 3 In Acidified Potassium permanganate							
	Ortho-organizer (N)					10 100%	10 100%
After 24	Percentage						
Hours	Ormco (N) Percentage				2 20%	8 80%	10 100%
	Ormco elastic modules (N)				2 10%	18 90%	20 100%
	Percentage						
	3M elastic modules (N)			3 30%	2 20%	5 50%	10 100%
	Percentage						
Group 3 In neutral Potassium permanganate							
Time		Purple	Red	Brown	Yellow	Clear	Total
	Ortho-organizer (N)	10					0 100%
After 5	Percentage	100%					
minutes	Ormco (N) Percentage	10					10 100%
		100%					
	Ormco elastic modules (N)	10					10 100%
	Percentage	100%					
	3M elastic modules (N)	10					10 100%
	Percentage	100%					
	Ortho-organizer (N)	8 80%	2 20%				10 100%
After 30	Percentage						
minutes	Ormco (N) Percentage	10					10 100%
		100%					
	Ormco elastic modules (N)	6 60%	3 30%	1 10%			10 100%
	Percentage						
	3M elastic modules (N)	10					10 100%
	Percentage	100%					
	Ortho-organizer (N)	2 20%	1 10%	4 40%	1 10%	2 20%	10 100%
After 8	Percentage						
hours	Ormco (N) Percentage	8 80%		2 20%			10 100%
	Ormco elastic modules (N)			3 30%	3 30%	4 40%	10 100%
	Percentage						
	3M elastic modules (N)	8 80%	1 10%	1 10%			10 100%
	Percentage						
	Ortho-organizer (N)			1 10%	2 20%	7 70%	10 100%
After 24	Percentage						
hours	Ormco (N) Percentage			3 30%	5 50%	2 20%	10 100%
	Ormco elastic modules (N)				2 20%	8 80%	10 100%
	Percentage						
	3M elastic modules (N)	5 50%	2 20%	2 20%	1 10%		10 100%
	Percentage						

animal in vivo testing.

7. Conclusion

The simple and affordable tests done in this study " do – it – yourself " indicate that the short- term threat of estrogenic leaking from dental managements using Bisphenol-A (BPA) grounded resins is negligeble, exploration should be focused at assessing the pharmacokinetics and pharmacodynamics of the long- term percolation of pollutants from BPA grounded polymer used in the oral cavity.

8. Source of Funding

None.

9. Conflict of Interest

None.

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Cite this article: Patil CB, Nayak RS, F. H. Tan K, G Chitte V. Evaluation of leaching from orthodontic polymers using a simplified chemical method - An in vitro study. *J Contemp Orthod* 2025;9(1):117-123.