

UNIVERSITI TEKNOLOGI MARA

**THE EFFECT OF FILLERS ON
MECHANICAL, PHYSICAL AND
THERMAL PROPERTIES OF
SILICONE FOR APPLICATION IN
EXTRAORAL PROSTHESIS**

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ABSTRACT

Problem statement: Oral cancer and other head and neck cancers can cause significant facial defects due to extensive surgical resections, which impair function and aesthetics, necessitating the use of custom-made extraoral prosthetics to restore appearance and functionality, improve quality of life, and address psychological impacts. Silicone, widely used for extraoral prostheses, deteriorates rapidly in Malaysia's hot and humid climate, reducing its lifespan. This study highlights the need for enhanced silicone materials with improved mechanical and thermal properties to increase prosthesis longevity and effectiveness, addressing both physical and psychological challenges faced by individuals with facial disfigurements. **Purpose:** This study investigates the mechanical, physical, and thermal properties of modified DC-L15 and DC-L20 room temperature vulcanised (RTV) silicones with titanium dioxide, calcium carbonate, and zinc oxide fillers at different percentage. It aims to characterize filler distribution, evaluate their effects, and analyse tear propagation. **Methodology:** This *in vitro* study consisted of three phases: Phase 1 SEM characterization of fillers, Phase 2 focused on evaluating physical, mechanical and thermal properties, and Phase 3 analysing tear propagation. DC-L15, and DC-L20 RTV silicones used, incorporating micron-sized fillers (titanium dioxide, calcium carbonate, and zinc oxide) at varying weight percentages (1, 2, 3, 4, and 5% w/w). The mixtures were moulded, cured, and labelled, resulting in 33 groups (n=5). The samples were characterized for filler distribution using SEM and assessed for density, tear strength, hardness, differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA). Statistical analyses included one-way ANOVA for density and Kruskal-Wallis for tear strength and hardness. DSC curves identified the onset of glass transition temperature (T_g) and melting temperature of unreacted monomer (T_m), while TGA curves traced the onset of solvent (T_i) and polymer degradation (T_j). Tear propagation was examined under optical microscope magnification, and correlations were drawn between the properties and SEM images. **Results:** The Scanning Electron Microscope (SEM) shows well dispersed fillers within silicone matrix for all three fillers. No statistically significant differences were observed in density, tear strength and hardness between DC-L15 and DC-L20 ($p \geq 0.05$). 3% w/w of zinc oxide was found to have the highest tear strength in both DC-L15 and DC-L20, and hardness in DC-L20. Glass transition temperature, melting temperature of unreacted monomer, solvent and full polymer degradation improved with incorporation of fillers. Although no clear correlation was found between tear strength and hardness. SEM images are in agreement with the mechanical properties observed in 3% w/w of zinc oxide. Incorporation of fillers affected the tearing propagation of silicone leading to irregular pattern of tear. **Conclusions:** Within limitation of this study, 3% w/w of zinc oxide can be considered to improve tear strength, hardness and thermal properties of silicone. This has proven that alternative RTV silicone with fillers enhancement is a promising option to be used for extraoral prostheses fabrication.

Keywords: Extraoral Prosthesis, Maxillofacial Prosthesis, Silicone, Fillers, SEM, Tear Strength, Hardness, Density, DSC, TGA

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CHAPTER ONE

INTRODUCTION

1.1 Research Background

Oral cancer is highly prevalent in the Asian region, with 240,736 new cases and 128,799 deaths reported in 2020 alone (Sung et al., 2021). This region accounts for 65.8% of global oral cancer cases, with a disproportionately high mortality rate of 74% (Sung et al., 2021; Cancer Research Malaysia, 2024). This significant threat is attributed to factors like lower socioeconomic conditions and cultural practices such as betel quid chewing and smoking (Rao et al. 2013). In Malaysia, oral cancer is among the top 20 most common cancers, with a five-year prevalence of 2,199 cases. Alarmingly, the incidence of oral cancer in Malaysia is expected to double by 2040 due to age-specific incidence rates and population growth (Ferlay et al., 2020).

Oral cancer and other head and neck malignancies often lead to significant facial defects due to the extent of surgical resections required. The removal of tumours from the oral cavity or surrounding areas can create substantial gaps in facial structure, impacting both appearance and functionality.

Surgical treatment for oral cancer frequently involves the removal of large portions of the oral cavity, including parts of the jaw, palate, or other critical areas (Sung et al., 2021). This extensive resection can result in noticeable facial deformities (Ferlay et al., 2020). The defects resulting from such surgery can severely affect essential functions such as speech, chewing, and swallowing (Perry & Frowen, 2006). These impairments can lead to challenges in maintaining proper nutrition and overall health (Ackerman et al., 2018). Additionally, the visible changes caused by these defects can lead to significant psychological distress. Patients may experience reduced self-esteem and difficulties in social interactions due to alterations in their appearance (Pruzinsky, 1992).

Nasopharyngeal cancer treatment often involves both radiation and surgical procedures, which can result in defects in the nasopharyngeal region (Yeh et al., 2021). These defects can affect facial aesthetics and functionality. Skin cancers, such as basal cell carcinoma or squamous cell carcinoma, that occur on the face may require the removal of large areas of skin, leading to visible disfigurements (Badash et al., 2019).