1. Introduction

1.1 Background

Scalp hair has no significant function in human survival beyond providing a degree of protection from solar rays, offering limited cushioning from physical trauma and playing a role in sexual attraction (Cash, 2001). The sociological and psychological importance of hair far outweighs its biological function. As arguably the easiest bodily feature to alter, for example, through cutting, colouring and styling, hair is a readily accessible means of self-expression and has become a key factor in external and internal perceptions of attractiveness (Cash, 2001). Furthermore, the international hair and scalp care market was valued in 2020 at 80.81 billion USD and is predicted to grow at a compound annual growth rate of 6.6% from 2021 to 20282(Grand View Research, 2021).

Given the social and financial interest in this field, it is surprising how much has yet to be understood. A substantial proportion of literature regarding hair characteristics has obtained values from experimentation on wool(Phillips, 1985), hair from a single donor(Yu et al., 2017) or single supplier(Breakspear et al., 2022), (Stapels and Wortmann, 2000),(Wortmann et al., 2006), (Jinks, Paul and Wortmann, 2015), or samples from multiple sources with insufficient context provided relative to the samples' specific origins(Oliver et al., 2020). The absence of an adequate system for classifying the hair types (Cloete et al., 2019), (Daniels, Fraser and Westgate, 2022) is both an example of missing information and a contributing factor towards the potential for current and future hair research data to be unreliable(Cloete et al., 2019). Historically, hair has been grouped by ethnicity, most commonly 'African' (Central, South or West Africa), 'Asian' (East Asia) and 'Caucasian' (North and West Europe) (Daniels, Fraser and Westgate, 2022), (Robbins, 2012). The invalidity of this classification method is discussed in depth in Section 2.5 of this report. Attempts have been made to quantify hair through other approaches and systems (Loussouarn et al., 2007) but do not encompass the full range of hair fibre qualities. A review article from 2019(Cloete et al., 2019) concluded that the best way to achieve this would be to populate a database with all hair properties, as none currently exists, and search for relationships between seemingly unrelated characteristics.

One property of hair that has been relatively unexplored is its glass transition, specifically regarding hydration. The current technique for hair washing means that hair regularly experiences full saturation in moisture. Additionally, depending on factors such as climate and season, high relative humidity levels are typical in many places around the world. It is inevitable that hair will experience fluctuations in hydration throughout the day. Finding the humidity-induced glass transition for a range of hair types will enable a better understanding of how to care for and protect hair. The data may also provide further insight into the relationships between the hair types.

1.2 Aims and Objectives

The overall goal of this project was to investigate how humidity affects the mechanical properties of hair, specifically its transition from a glassy state to a rubbery state with increasing moisture. Using a structural protein fibre, such as hair, can give us unique insights that are transferable to a range of other natural materials (Rouse and Dyke, 2010). Additionally, the study of human hair is ongoing, and the effect of humidity on the glass transition of a broad range of hair types has yet to be investigated.