



Influence of SDBS on Keratin Extraction from Human Hair

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Abstract

The goal of the study is to use an aqueous SDBS (sodium dodecylbenzene sulfonate) based alkali-reduction dialysis process to extract out keratin from human hair debris. The FT-IR analysis was used for the confirmation of keratin. The extracted keratin was yielded 74%. Furthermore, FT-IR reveals that throughout the extraction procedure, the structure of keratin changed from an alpha helix to a beta sheet.

Keywords: Human Hair, Alkali-Reduction, Keratin, SDBS, FT-IR

Introduction

Keratin is mainly found in wool, feathers, hairs, nails, reptile skin¹. Keratin, a type of biological macromolecule has been widely used in biology, medicine, chemicals, and other fields in past years². Keratin generated from hair, in particular, has a substantially larger amount of cystine residues, resulting in tougher and more lasting structures through the creation of intermolecular disulfide bonds.^{3,4} To extract keratin, two main chemical techniques based on oxidation and reduction chemistry have been devised.^{6, 10-12} Other methods for keratin extraction from keratin-rich materials that are routinely employed are alkali extraction¹⁴ microwave irradiation¹⁵ steam explosion¹⁶ and by means of ionic liquids.¹⁷

In general, disulfide bonds are broken and generated into thiols (-SH) during the reductive method among others, which tend to be reoxidized back into disulfide bonds. As a result, the thiols in reductive keratin

must be prevented. The cystine sulfur atoms in oxidized keratin are in the form of sulfonic acid and thus unable to form disulfide cross-links due to the oxidization technique. Physical entanglements and hydrophobic interactions, as well as disulfide cross-linking, would make reductive keratin more stable.¹¹ On the basis of thiols prevention alkali reduction method can be useful technique to extract out keratin from human hair.

Surfactant is a self-assemble organic molecules, which have both polar & nonpolar in nature. Due to its better physico-chemical properties, it will have a wide range of applications. In recent years, surfactant have been found a key material to extract out natural materials. Recently, SDS based system have been used to extract out keratin from human hair.¹⁸ However, on the basis of our literature survey, SDBS based alkali reduction method have not reported to extract out keratin from human hair yet.

On the above basis, we have extracted keratin from human hair with the help of aqueous SDBS (sodium dodecyl benzene sulfonate) based alkali (sodium sulfate/ NaOH) – reduction dialysis method at room temperature. The extracted keratin was characterized by FT-IR analysis.

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Experimental

Materials: Human hair sample (Mr. Barber, local unisex saloon, Vadodara), urea (90%, Suvidhinath laboratory), 2-mercaptoethanol (98%, Corporation), calcium chloride (90%, Suvidhinath laboratory), NaOH (98%, Attar laboratory), SDBS (99%, Sigma Aldrich), Ethanol (95%, Hayman), dialysis membrane-100 (Himedia laboratory), deionized water (99% purity, Merck life science)

SDBS based Alkali-reduction Dialysis method: Human hair sample (1gm) was collected from a local saloon and chopped in small fine pieces. The sample washed with 70% ethanol, aqueous sodium dodecylsulphate and distilled water at room temperature. After washing, the sample was dried at room temperature for several hours. Chopped hair sample (1gm), distilled water (100ml), urea (9gm), SDBS (0.105gm) and 2-mercaptoethanol (0.96gm) was taken in three neck 250 ml clean and dry round bottom flask and reflux for 48 h at 70°C (Fig. 1). pH was adjust between 9 to 10 with the help of sodium hydroxide solution (drop by drop addition) during the whole reaction. The resulting mixture was centrifuge at 4000 rpm for 30

minutes followed by filtration with the help of Whatman filter paper. The resulting filtrate solution was dialyzed against milli-pore-Q water (contain 1% 2-mercaptoethanol). After 48 h of dialysis, the concentrated mixture of keratin was characterized by spectroscopic (FT-IR) analysis.

FT-IR Analysis: The extracted liquid concentrated keratin sample have been characterized by FT-IR (Perkin Elmer Spectrum Two, 0.1cm^{-1} accuracy and 0.01cm^{-1} precision) at room temperature.

Results and Discussion

SDBS-alkali reduction based extraction of keratin from human hair have been performed in aqueous solution at room temperature. The yield is obtained $\sim 74\%$, which is in line with earlier reports¹⁸. This showing a validity of our experiments.

Spectroscopic analysis of extracted Keratin: The extracted keratin sample has been analyzed by FT-IR analysis (Fig. 2). Stretching vibration of N-H amide band occurs in between the range of $3500\text{-}3400\text{cm}^{-1}$ (Table 1). The amide I band, stretching vibration attributed to C=O range falls in between $1700\text{-}1600\text{cm}^{-1}$. β -sheet band is connected with intense peak at 1653cm^{-1} , α -sheet absorption band is connected with range of 1545cm^{-1} . The range $1500\text{-}1450\text{cm}^{-1}$ is attributed to C-N stretching and N-H bending vibration which occurs in the amide II band. This peak is attributed α -helix is 1554cm^{-1} , whereas the β -sheet peak is attributed at 1545cm^{-1} . The amide III band range falls in $1300\text{-}1200\text{cm}^{-1}$, and is attributed with N-H and O=C-N bending vibration and C-N and C-O.

The findings show that during the hair disintegration process, the supramolecular structure of isolated keratin changed from α to β sheet. In the extracted keratin, which occurs in the range of $1200\text{-}1000\text{cm}^{-1}$, there are several novel functional groups compared to raw hair. The asymmetric and symmetric S-O stretched vibrations of the cystine oxides should be allocated to these peaks at 1022cm^{-1} , 1045cm^{-1} , and 1066cm^{-1} . Finally, the symmetric and asymmetric S-O starching vibrations are linked to the strong peaks at 1035cm^{-1} and 1126cm^{-1} . The keratin protein molecule has been clearly indicate with the help of amide III bond. This thing suggest that the molecular structure of keratin is remain same. However the position and boding (like, sulfide and hydrogen) of the sheet is going to change, from α to β due to their extra stretching (Fig. 3).

Conclusions

In summary, human hair has been used to extract keratin by SDBS based alkali reduction / dialysis method at room temperature (30°C). Aqueous keratin solution was obtained at a rate of 74%, which is in line with reported data. Characteristics of extracted keratin have been performed by FT-IR analysis. The amide-III (1300-1200 cm⁻¹) clearly indicate that the presence of keratin protein molecule. The data showing that the keratin supramolecular structure is transformed from α to β -sheet. This study will be helpful in the different cosmetic applications, like straightening hair, cosmetic, shampoo, etc.

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References

1. M. Zoccola, A. Aluigi, C. Vines, C. Tonin, F. Ferrero and M.G. Piacentino, *Biomacromolecules*, **9**, 2819 (2008).
2. M.B. Dickerson, A.A. Sierra, N.M. Bedford, W.J.W.E. Lyon, A. Mirau and R.R. Naik, *J. Materials Chem. B*, **1**,5505 (2013).
3. J.G. Rouse and M.E. Van Dyke, *Materials*, **3**, 705 (2010).
4. A. Tachibana, Y. Furuta, H. Takeshima, T. Tanabe and K. Yamauchi, *J. Biotechnol.*, **93**,165 (2002).
5. K. Yamauchi, A. Yamauchi, T. Kusunoki, A. Kohda and Y. Konishi, *J. Biomed Mater Res.*, **31**, 439 (1996).
6. P.M.M. Schrooyen, P.J. Dijkstra, R.C. Oberthür, A. Bantjes and J. Feijen, *J. Biomed. Mater Res.*, **48**, 4326 (2000).
7. J. Yuan, J. Shen and I.K. Kang, *Polymer Int.*, **57**, 1188 (2008).
8. A. Nakamura, M. Arimoto, K. Takeuchi and T. Fuji, *Bio Pharm. Bull.*, **25**, 569 (2002).
9. S. Wang, F. Taraballi, L.P. Tan and K.W. Ng, *Cell Tissue Res.*, **347**, 795 (2012).
10. P. Sierpinski, J. Garrett, J. Ma, P. Apel, D. Klorig, T. Smith, L.A. Koman, A. Attala, and M. Van Dyke, *Biomaterials*, **29**, 118 (2008).
11. S. Tomblyn, E.L. Pettit Kneller, S.J. Walker, M.D. Ellensburg, K.C.J. owalczewski, M. Van Dyke, L. Burnett, and J.M. Saul. *J Biomed, Mater Res. Part B*, **104**, 864 (2016).

12. K. Yamauchi, A. Kusunoki, A. Kohda, and Y. Konishi, *J Biomed Mater Res.*, **31**, 439 (1996).
13. J.H. Buchanan, *Biochem.* **167**, 489 (1977).
14. Y. Tsuda and Y. Nomura, *Anim. Sci. J.*, **85**, 180 (2014).
15. M. Zoccola, A. Aluigi, A. Patrucco, C. Vineis, F. Forlini and P. Locatelli, *Textile Res. J.*, **82**, 2006 (2012).
16. C. Tonin, M. Zoccola, A. Aluigi, A. Varesano, A. Montarsolo and C. Vineis, *Bio-macromolecules*, **7**, 3499 (2006).
17. H. Xie, S. Li and S. Zhang, *Green Chem.*, **7**, 606 (2005).
18. J. Shui-qing, Z. Lin, W. Haixia and Chi Gang, *Int. Ferroelectrics*, **180**, 102 (2017).

Figure Captions

Fig. 1. Schematic representation of Keratin extraction from human hair

Fig. 2. Fourier-transform infrared spectroscopy (FT-IR) spectra of extracted keratin from human hair.

Fig. 3. Schematic representation of Keratin Structure (α and β)

Table Captions

Table 1. FT-IR Spectra data of extracted keratin from human hair

Tables

Table 1. FT-IR Spectra data of extracted keratin from human hair

Wave Length (cm ⁻¹)	Bond	Functional Group	Type
3500-3400	N-H-I	Primary amide	Medium
1700-1600	C=O	Carbonyl	Medium
1545	α -helix	-	Strong
1653	β -sheet	-	Intense peak
1500-1450	C-N	Carbon – nitrogen	Strong
1554	N-H-II	Secondary amide	Strong
1300-1200	N-H-III	Tertiary amide	Intense peak
1200-1000	O=C-N	-	Medium
1035-1126	S-O	Sulfonyl	Strong

Figures

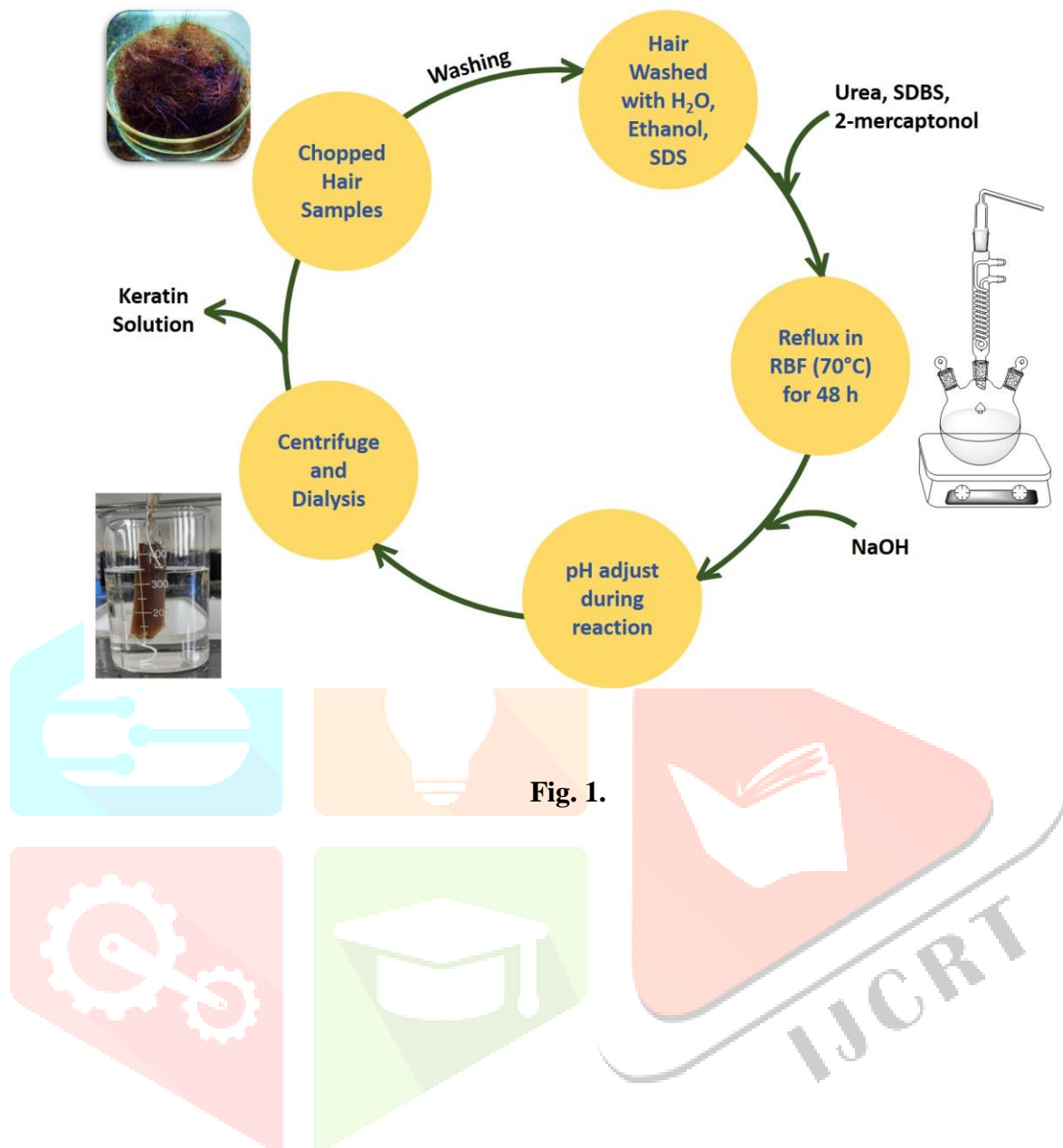


Fig. 1.

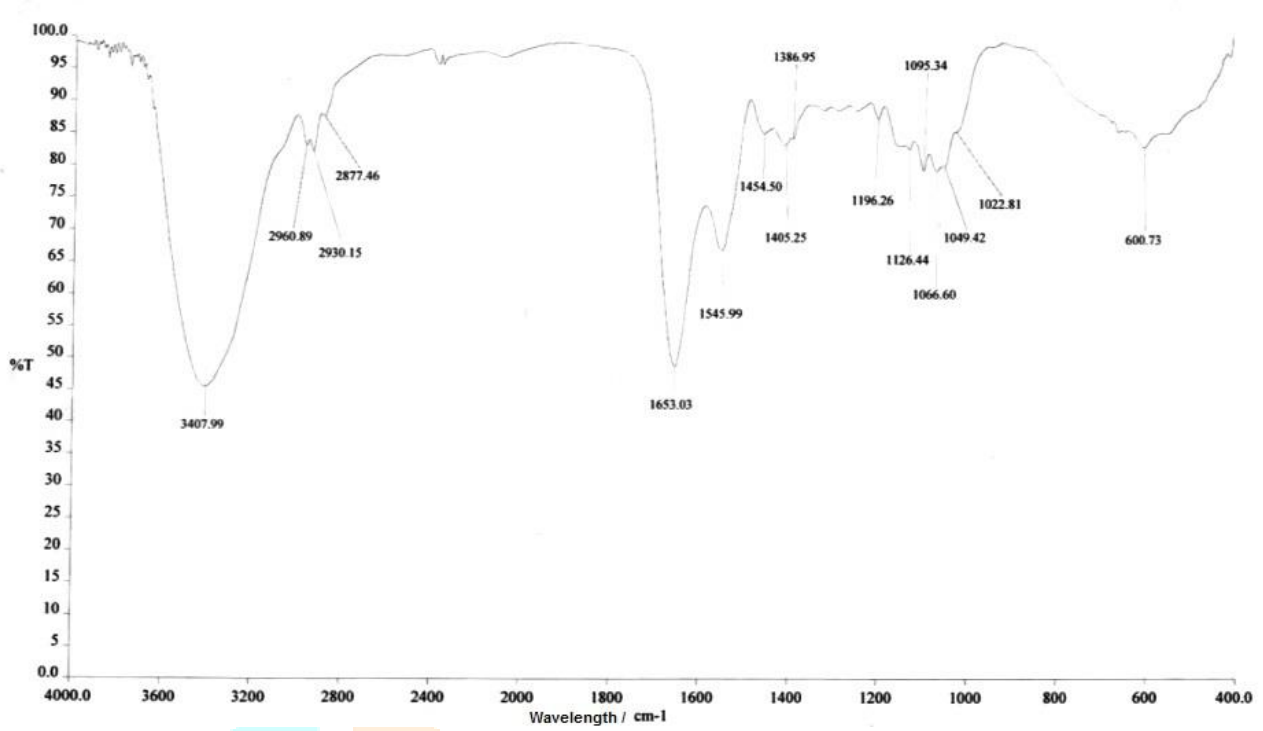
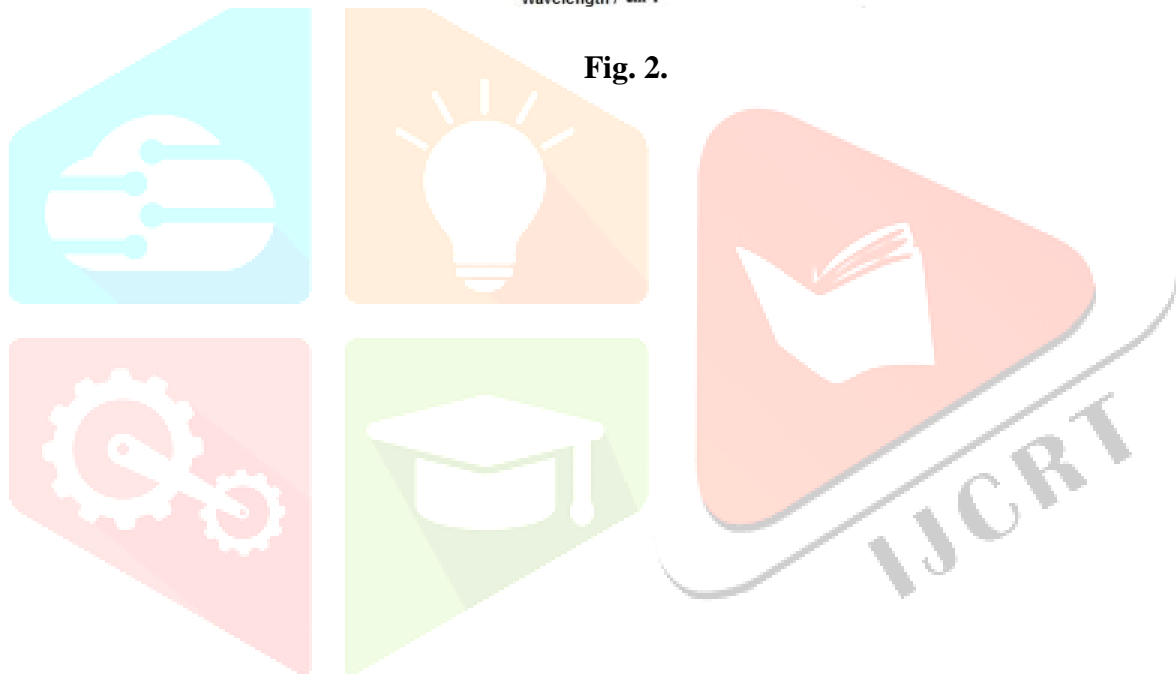


Fig. 2.



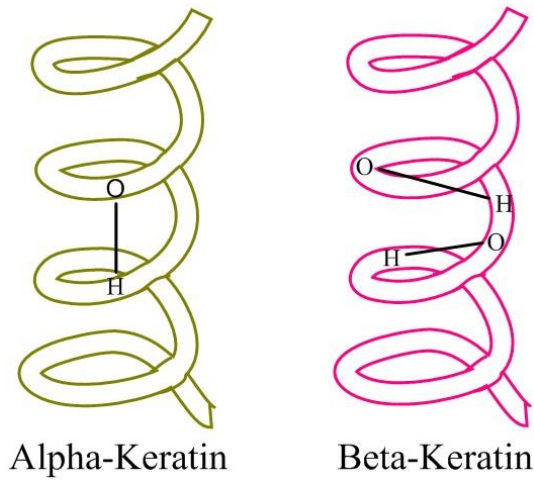


Fig. 3.

