APPENDIX
PAPERS PRESENTED IN NATIONAL / INTERNATIONAL CONFERENCES
1. A paper titled “Synthesis and Characterization of nano hydroxyapatite/poly (1,6 hexane diol-succinate-citrate)composite” Jaisankar V and Indira R “National conference on Recent advances in Green Chemistry” held at Vels University, Chennai, Tamil Nadu, India on 18th and 19th August 2013.


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Synthesis and Characterisation of Certain Novel Polyester Elastomers

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ABSTRACT
In this paper, we report on the synthesis of certain novel polyester elastomers namely as Poly[poly(ethylene glycol) sebacate citrate], PEGSeCa and Poly[poly(ethylene glycol) sebacate citrate], PEGSeSc, by carrying out catalyst free polycondensation of multifunctional non-toxic monomers: poly(ethylene glycol) (PEG), citric acid (CA) and sebacic acid (SA)/sebacic acid (SA). The polyesters were characterised by solubility, viscosity measurements, IR, 1H NMR and 13C NMR spectral methods. The thermal properties were studied using differential scanning calorimetry. The swelling behaviour of the synthesised polyesters were studied. We demonstrate that the chemical structure, morphology, physical integrity and surface property of the synthesised copolyesters can be controlled by simply changing the monomers. These novel polyesters exhibit versatility in thermal properties, hydrolysis and hydrolytic degradation as determined by the chemical structure of the polyester elastomers. The synthesised polyesters are potential elastic biomaterials for tissue engineering.

Keywords: Elastomers; Polycondensation; Biomaterials; Citric Acid.

1. INTRODUCTION
In recent years, biodegradable polymers have gained considerable interest in various fields of biomedical engineering including tissue engineering and drug delivery, where cell-seeded constructs are designed to replace damaged or diseased tissues [1,2]. Tissue engineering is emerging as a new multidisciplinary research field in regenerative medicine. The main strategy involves tissue regeneration by basic tissue-specific cells that are seeded into specifically designed synthetic matrices called scaffolds [3-5]. The main guiding principle in scaffold development is that the scaffolding material should resemble the natural extracellular matrix of the target tissue. In order to successfully engineer many of the native tissues, the resulting scaffold must be strong enough to withstand the mechanical demands asserted upon them once implanted inside the body, and be able to transfer mechanical stimuli to the newly developing tissues [6-10].

The synthesis of elastomeric biodegradable polyesters needs more attention due to wide range of medical applications [11-14]. Biodegradable elastomers are advantageous in that they can sustain and recover from multiple deformations without causing irritation to the surrounding tissue. Numerous biodegradable elastomers have been developed for tissue engineering and have found widespread application in the engineering of blood vessels, heart valves, nerves, cartilage, skin, bladder and bone. Among these materials, citric acid derived bioelastomers have been shown to offer a wide range of controllable mechanical profiles along with surface affinities towards many cell types. This new class of bioelastomers are synthesised with non-toxic monomers using simple and cost effective methods. The common monomer used in these biomaterial is citric acid which is a non-toxic metabolite product of the Krebs cycle and has been approved by the food and drug administration. Citric acid is also a reactive monomer that can participate in hydrogen bonding in the polyester network. Hence, we report on the synthesis and characterisation of new polyester elastomers containing citric acid in combination with aliphatic diols as comonomers by catalyst free reaction. The synthesis and characterisation of two polyesters: Poly[(ethylene glycol) citrate-co-poly[(ethylene glycol) sebacate], PEGSeCa and Poly[(ethylene glycol) citrate-co-poly(ethylene glycol) sebacate], PEGSeSc. The monomers used for the synthesis are biodegradable polymers and so toxicity was expected to be low.

2. EXPERIMENTAL
2.1. Materials
Citric acid (Merck AR grade), Suberic acid (Lancaster AR grade) and Sebacic acid (Merck AR grade) were recrystallised from deionised water and used. Poly(ethylene glycol) (Merck AR grade) was dried with CaO overnight and then distilled under reduced pressure. All the other materials and solvents used were of analytical grade.

2.2. Synthesis of Copolyesters

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Synthesis and Characterisation of Citric Acid based Polymeric Nanocomposite

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ABSTRACT

Nanohydroxyapatite powders were synthesised by sol-gel method using calcium nitrate and phosphoric acid as calcium and phosphorus precursors, respectively. The powders were sintered at 100°C, 300°C, 500°C, 700°C and 900°C and characterized by XRD, SEM, FT-IR and TGA-DTA analysis. The average crystalite size was also calculated. We have also prepared the nanohydroxyapatite/poly(1,8 octane diol-adipate-citrate) nanocomposites (n-HAp/POAC) which has potential application in soft tissue engineering. The composites consist of the biodegradable polyester prepared from 1,8 Octane diol, Adipic acid and Citric acid together with nanohydroxyapatite. The structure of composites were characterized by solubility studies, FT-IR, 1H NMR and 13C NMR spectral studies and thermal analysis. Thermal studies showed that the glass transition temperature, Tg, of the composites decreased with increase in n-HAP contents. Thin films and porous scaffold were fabricated to demonstrate their ease of processing. Mechanical studies illustrates that the polymer were cross-linked elastomers. The morphology of the polyester and nanocomposite thin films were studied using by SEM.

Keywords— Nanohydroxyapatite, sol-gel method, glass transition temperature, elastomers

1. INTRODUCTION

In recent years, there has been increasing attention in using citric acid as a robust multifunctional monomer for biomaterials synthesis, i.e., trifunctional citric acid can react with alcohols or polyols to form esters without any catalyst. This reaction is reported to occur via reactive anhydride intermediate, followed by its reaction with alcohol with a large extent of intramolecular cross-linking. The probability of such networking can be increased by controlling the concentration of the precursors. The resulting chemical structure and processing determine the physical integrity of the synthesized elastic material(1). As many tissues in the body have elastomeric properties, successful replacement or restoration of these tissues will require the development of compliant biodegradable elastomeric scaffolds that readily recover from relatively large deformations without mechanical irritation to the host(2).

Degradable biocelastomers have been one of the significant research focuses in the past few years. Biodegradable aliphatic polyester elastomers have been recognized as one of the most promising biodegradable materials because they are easily susceptible to biological attack and their degradation products are non-toxic and can enter the metabolic cycles of bio-organisms(3,4).

Tissue engineering, which applies methods from engineering and life sciences to create artificial constructs to direct tissue regeneration, has attracted many scientists and surgeons with a hope to treat patients in a minimally invasive and less painful way.(5)

Generally, polymer nanocomposites are the result of the combination of polymers and inorganic/organic fillers at the nanometer scale. The extraordinary versatility of these new materials springs from the large selection of biopolymers and fillers available to researchers. Existing biopolymers include, but are not limited to, polysaccharides, aliphatic polyesters, polypeptides and proteins, and polynucleic acids, whereas fillers include clays, hydroxyapatite, and metal nanoparticles.(6)

Producing bionanocomposites based on biomimetic approaches has been a recent focus of researchers. Among these materials, hydroxyapatite (HAp)-polymer nanocomposites have been used as a biocompatible and osteoconductive substitute for bone repair and implantation.(7,8). As the main inorganic component of hard tissue, HAp [Ca10(PO4)6(OH)2] has long been used in orthopedic surgery. However, HAp is difficult to shape because of its brittleness and lack of flexibility. HAp powders can migrate from implanted sites, thus making them inappropriate for use. Moreover, these powders do not disperse well and agglomerate easily(9).

Furthermore, processing under high temperatures can cause changes in crystallinity and Ca/P stoichiometry(10). Therefore, the incorporation of HAp in polymeric nanocomposites to overcome processing and dispersion challenges is of great interest to the biomedical
ynthesis and Characterization of Novel Bio-Elastomers for Tissue Engineering

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ABSTRACT:
Biodegradable elastomers have recently found widespread application in many areas of biomedical engineering such as tissue engineering, therapeutic delivery and bioimaging. Recent developments led to development of elastomers involving citric acid based polyesters are being explored that are endogenous to the human metabolism. In terms of mechanical stability, crystallinity, hydrophobicity and biocompatibility, polyesters synthesised from these monomers can display a wide range of applications. In this investigation, a series of novel bio-elastomers based on citric acid were synthesised by catalyst free polycondensation reaction. These polymers were characterised by solubility, IR, 1H NMR, spectral analysis, thermal and mechanical studies. The physicochemical properties of the synthesised polymers are controlled by the variation of monomers in polycondensation reaction forms a pivotal role in the synthesis.

KEYWORDS: Biodegradable elastomers, biocompatibility, polycondensation, spectral analysis

INTRODUCTION:
Biodegradable polymers have made a considerable impact in various fields of biomedical engineering including tissue engineering and drug delivery, where cell-seeded constructs are designed to replace damaged or diseased tissues[1-3]. Biodegradable elastomers are advantageous in that they can sustain and recover from multiple deformations without causing irritation to the surrounding tissue in a mechanically demanding environment[4-5]. In recent years, catalyst-free synthesis has emerged as a potential route to synthesise elastic polyesters with appropriate mechanical integrity, suitable surface characteristics and compatibility for fabrication of tissue engineering scaffolds[6]. Various polyester elastomers, synthesized so far from low-cost and nontoxic precursors such as 1,8-Octanediol (OD), citric acid (CA), glycerol and sebacic acid (SA), represent a new generation of advanced biocompatible and biodegradable synthetic materials with potential biomedical applications[7-8].

It has been recognized that cross-linking confers elasticity to the polymers as similar to those naturally occurred cross-linked polymers such as collagen and elastin.

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PGS and poly(diol citrates) are soft and elastomeric cross-linked polyester networks and the mechanical properties of these polymers have been shown to match those of the soft tissues such as cardiac tissues and blood vessels in the body, thus considered as suitable candidate materials for soft tissue engineering[9-10]. Specifically, poly(diol citrates) hold significant promise for use in vascular tissue engineering due to their anticoagulant properties, ability to support the adhesion, proliferation, and differentiation of endothelial cells and reduced platelet adsorption and activation[11].

Citic acid is a versatile monomer that participates in prepolymer formation through a simple polycondensation reaction while preserving pendant functionality for post polymerisation to produce a crosslinked polyester network with degradable ester bonds. Crosslinking confers elasticity to the polymers similar to the extracellular matrix, in which collagen and elastin are all crosslinked polymers[12]. Citric-acid-derived biodegradable elastomers (CABEs) such as poly(diol citrate), cross-linked urethane-doped polyesters (CUPE), elastomeric cross-linked biodegradable photoluminescent polymers (CBPLPs), poly[xylitol-citrate], etc., have recently received significant attention in various biomedical applications, including tissue-engineering orthopedic devices, bioimaging and implant coatings[13-15]. Malic acid, an important component of the
Synthesis And Characterisation Of Nanohydroxyapatite/Poly(1,6 Hexane Diol-Succinate-Citrate) Composite

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Abstract

In recent years, there is an increasing demand for biodegradable polymeric nanocomposites which are used as potential biomaterials in tissue engineering. In this investigation, citric acid based polyester [poly(1,6 Hexane diol-Succinate-Citrate), PHSC] was synthesised by catalyst free polycondensation method and Nanohydroxyapatite(n-HAp) powders were synthesised by sol-gel method using calcium nitrate and phosphoric acid as calcium and phosphorus precursors, respectively. The nanohydroxyapatite powders were characterized by FT-IR, XRD and SEM. The nano hydroxyapatite-polymer composite was prepared by solution casting method. The composite was characterised by solubility studies, FT-IR, $^1$H NMR and $^{13}$C NMR spectral studies and thermal analysis. Thermal studies showed that the glass transition temperature, Tg, of the composite decreased with increase in n-HAp contents. The morphology of the polyester and nanocomposite thin films were studied using by Scanning Electron Microscopy (SEM).

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Keywords: Nanohydroxyapatite, Catalyst free polycondensation, Sol-gel method, Glass transition temperature.