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Convergence Formulation studies of Diagnostic Ultrasound Transmission Media:focusing on the manufacturing costs and rheology

Hye-Nam Lee[*], Mi-Soon Park[**], Yeon-Hwa Park[***]

Dept. of Radiological Wonkwang Health Science University[*]

Dept. of Pathology Korea Clinical Laboratory[**]

Dept. of Radiological Science Konyang University[***]

초음파전파매개물의 융복합 제형 연구 :제조비용, 윤활성에 대하여

이혜남, 박미순, 박연화

원광보건대학교 방사선과, 한국임상의학연구소, 건양대학교 방사선과,

Abstract In this study, by combining a unique purpose and additional aspects of ultrasonic transmission media, a development potential on a new ultrasonic transmission media was sought. The rheological characteristics and the manufacturing cost for each manufactured formulation were compared and analysed with ready-made. An ultrasonic transmission media is to have different functional characteristics according to the following formulation, it was the best in rheological value, low viscosity emulsion with the oil gel. Polymer hydro gel is can be manufactured at low cost compared to other formulations. Emulsion which shows a sharp viscosity difference according to the components of oil and water had a big difference in manufacturing cost. This study can be utilized as the fundamental data on the ultrasound transmission media equipped with expertise in various areas of ultrasound.

Key Words : Ultrasound Transmission Media, Formulation Type, Manufacturing cost, Convergence, Wellbeing

요 약 본 연구에서는 초음파매개물의 1차적인 목적이외에 부가적인 특징을 조합하여 새로운 초음파매개물의 개발 가능성을 모색하였다. 임의 제조된 각 제형에 따른 유동학적 특징과 제조비용을 기성품 제제와 비교 분석하였다. 초음파전파매개물은 제형에 따라 각기 다른 기능적 특성을 지니게 되며, 저점도에멀전과 오일젤에서 유동성이 가장 우수하였다. 제조비용에서는 수화젤 제형이 물성분이 많을수록 제조비용이 가장 낮았으며, 에멀전과 오일젤 제형에서는 오일의 함유량이 높을수록 제조비용에 많은 차이가 있었다. 본 연구는 초음파의 다양한 영역의 전문성을 겸비한 새로운 초음파매개물의 연구에 대한 초석을 이룰 수 있을 것으로 사료된다.

주제어 : 초음파투과매개물, 제형, 제조비용, 융복합, 웰빙

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Corresponding Author:Yeon-Hwa Park

(Dept. of Radiological Science Konyang)

Email:hnlee@wu.ac.kr

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1. Introduction

Since the year 2000 with the formation of social consensus on health-oriented value called the wellbeing, a wellbeing consumption phenomenon has spread throughout the society[1]. Economists claimed that wellbeing culture will create a new lifestyle and constantly change the consumption and lifestyle patterns[2].

Since the 1990s coming into 2000s, high-definition and high performance ultrasonic devices were introduced in clinical practice and today, away from a simple diagnostic area of screening program, it is being spread to the entire area of medical service[3]. In addition, even in the medical industry the ultrasonic diagnostic devices occupy a large proportion[4,5]. Ultrasonic transmission media must be applied in order to deliver the ultrasound energy into the examining tissue without any loss[6,7].

The ultrasonic transmission media commonly used in current clinical practice is polymer hydro gel form. Actually clinical centers often complain of skin discomfort during the examination and the economic losses are weighted for wiping the gel after using.

Since the full-scale introduction of ultrasound in clinical practice and in contrast to the rapid development of its performance, a study on the ultrasonic transmission media was not entirely satisfying[8,9]. Actually formulation studies of ultrasonic transmission media is difficult to find abroad.

Therefore in this study, by combining a unique purpose of ultrasonic transmission media for delivering a conventional ultrasound and additional aspects such as health of the skin, convenience and emotional aspects, a developmental potential on a new ultrasonic transmission media was sought. Especially, among the various characteristics required by ultrasonic transmission media, rheological characteristics and manufacturing cost were analysed and compared on the different formulations of media.

With sophistication and diversification of ultrasonic transmission media that meets the wellbeing trend, it is thought to be able to achieve the groundwork for a new future oriented ultrasonic transmission media.

2. Method

2.1 Subject

This study was conducted with respect to the two types of emulsion and oil gel without water content as well as four different forms polymer hydrogel. To do so, we a purchased commercialized hydrogel, which is commonly used in clinical practice and concocted others on our own in 2013 . Commercialized hydrogel was named as no.1 and hydro gel produced according to a arbitrary composition was named as no.2. Based on the no.2, the hydro gel having higher ratio of thickener was named no.3 and the hydro gel having higher ratio of moisturizer was named no.4. In the O/W emulsion formulation, low viscosity emulsion having lower oil contents than water was named no.5, high viscosity emulsion having higher oil contents than water was named no.6 and oil gel formula without water was named no.7.

2.2 Ingredient of manufacturing formulation

The formulation, 3 types of polymer hydro gel, oil gel, 2 types of emulsion was manufactured as follows arbitrary<Table 1,2,3>.

〈Table 1〉 Formulation of Polymer hydro gel.

unit:(w/w%, won*)

Ingredients	Formulation		
	no.2	no.3	no.4
M-P	0.1(0.70)	0.1(0.70)	0.1(0.70)
Phenoxyetha-nol	0.1(1.00)	0.1(1.00)	0.1(1.00)
Lavender Oil	0.03(0.60)	0.03(0.60)	0.030.60)
HCO-40	0.1(1.00)	0.1(1.00)	0.1(1.00)
1,3 BG	2.0(10.00)	2.0(10.00)	5.0(25.00)
Glycerin	3.0(9.00)	3.0(9.00)	10.0(30.00)
KDA-1254	0.1(2.00)	0.1(2.00)	0.1(2.00)

Carbopol -980	0.4(12.00)	0.8(24.00)	0.4(12.00)
TEA(10% Soln)	4.0(1.20)	8.0(2.40)	4.0(1.20)
Water	90.17(0.00)	85.77(0.00)	80.17(0.00)
Total	100(37.50)	100(50.70)	100(73.50)

*Unit Price per 100g

〈Table 2〉 Formulation of oil in water emulsions.

unit:(w/w%, won*)

	Ingredients	Formulation	
		no.5	no.6
Oil phase	Cetostearyl alcohol	0.5(3.00)	3.0(18.00)
	Glyceryl stearate	1.0(4.00)	1.0(4.00)
	Glycerylstearate/PEG-100 stearate	1.0(6.00)	1.0(6.00)
	Caprilic/Capric Triglyceride	3.0(21.00)	3.0(21.00)
	Mineral oil	10.0(30.00)	40.0(120.00)
	Propylparaben	0.1(1.00)	0.1(1.00)
	PEG-40 stearate	1.0(6.00)	1.5(9.00)
	Sorbitan stearate	0.5(3.00)	0.5(3.00)
	Dimethicone	0.3(1.80)	0.3(1.80)
Water phase	Water	72.13(0.00)	26.3(0.00)
	1,3 Butylene glycol	5.0(25.00)	5.0(15.00)
	Glycerin	5.0(15.00)	5.0(25.00)
	Methylparaben	0.2(1.40)	0.2(1.40)
	Triethanolamine (10% Soln)	0.12(0.36)	0.9(0.36)
	Carbopol 980 (1% Soln)	0.12(3.60)	12.32(3.60)
	Lavender oil	0.03(0.60)	0.03(0.60)
Total		100(121.76)	100(229.76)

*Unit Price per 100g

〈Table 3〉 Formulation of oil gel. unit:(w/w%, won*)

Ingredients	Formulation
	no.7
Dextrin palmitate/ethylhexanoate	10.0(1500.00)
Mineral oil	90.0(270.00)
Total	100(1,770.00)

*Unit Price per 100g

2.4 Measurement of rheological characteristics

In order to examine the rheological characteristics of each media, a Discovery Hybrid Rheometer was used. The amount of the medicine has used 1.5㎖ and the measurement temperature was constantly maintained at 25± 1℃ by constantly circulating the water temperature with a thermostat. By applying the media into the measurement cell and by changing the shear rate to 0-1001/s, the changes of shear stress was measured to create the rheogram. In addition, the stress sweep test was conducted in the range of 1-104 Pa with the frequency of 1 Hz to measure the storage modulus(G′).[Fig.1]

(a) (b)

[Fig. 1] Geometry of rheometer sensor system of standard Peltier Plate(a) and the photograph of TA Instruments Discovery Hybrid Rheometer(Model DHR, TA Instruments, USA)(b)

2.5 Manufacturing cost calculation

In this study, the manufacturing cost was calculated using the processing method of direct material cost which is a value calculated by multiplying the amount of material and unit cost. Standard price for material was calculated based on 100g and the value added with contents was used as the standard. Especially, the E gel(no.1) currently being sold in the market was substituted with the price set forth in this study based on Material Safety Data Sheet and Certificate of Analysis provided by the maker[10].

3. Result

3.1 rheological characteristics

For each media, the yield stress(τ) on the shear rate(γ̇) was measured using the rheometer and the storage modulus(G′) which represents the properties of solid on the stress and the loss modulus(G′′) which represents the properties of liquid was measured. As a result, the yield stress and viscosity on low viscosity emulsion(no.6) and oil gel(no.7) were the lowest. The

yield stress of low viscosity emulsion and oil gel were 8.51 Pa and 14.66 Pa

〈Table 4〉 rheological value according to the formulation

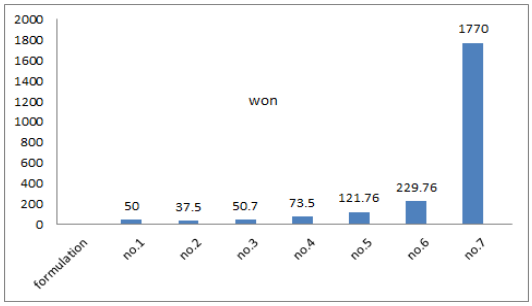
Sample No.	Yield stress(Pa)	Viscosity(Pa/s)	G′- G′′value
no.1	41.94	1.27	100
no.2	18.07	0.64	80
no.3	35.62	1.28	100
no.4	16.53	0.73	50
no.5	8.51	0.44	20
no.6	95.26	2.16	100
no.7	14.66	0.38	20

G′- G′′value : The strength required for changing the rheological characteristics of media

respectively, and the viscosity was 0.44 Pa/s and 0.38 Pa/s. The strength required for changing the characteristics of liquid and solid properties was shown as 20 Pa which was the lowest among the medicines. The yield stress of ready-made hydro gel was 41.94 Pa, viscosity was 1.27 Pa/s and the strength required for changing the characteristics of liquid and solid properties was approximately 100 Pa.

3.1 Manufacturing material costs

commercialized polymer hydrogel, no.1 which was calculated based on Material Safety Data Sheet and Certificate of Analysis was 50 won.



[Fig. 2] Raw material cost according to the formulation type of ultrasonic transmission media

The average cost of media, concocted polymer hydro gel on our own no.2, no.3 and no.4 was 53.90 won and no.4, a polymer hydro gel type having high moisturizing content such as glycerin was 73.5 won showing the highest among polymer hydro gels. The average cost of materials for emulsions no.5 and no.6 was calculated as 175.76, a low viscosity emulsion no.5 having lower oil content than water was 121.8 won and high viscosity cream type emulsion no.6 having higher oil content than water was calculated as 229.7 won. The cost for oil gel no.7 was shown as 1,770 won.

4. Discussion

Ideal ultrasound transmission media should be fundamentally equipped with characteristics such as lubricity of the skin, moisturizing, ultrasound properties, convenience during inspection and affordability.

In the rheological experiment of this study, low viscosity emulsion and oil gel was the best compared to the hydrogel with the cheapest manufacturing cost. According to the reference, Rheological parameters has related to the sensory parameters which are removing from a package, ease of spreading, skin feel and thickness[11].

For lubricity in the skin, the type with low viscosity and friction with large liquid index is excellent, but during the actual ultrasound inspection, physical lubricity may be further increased as the thixotropy may increase due to heat of the ultrasound transducer or the skin conditions due to temperature and salinity[12].

Water as the ultrasonic transmission media can absorb a very small amount of ultrasound with excellent penetration of sound and can be obtained easily from surrounding so it has the advantage as the ultrasonic transmission media[13]. But having a faster evaporation rate due to the nature of water means that it becomes the cause that lead to inconvenience of

reapplying the media during the inspection with heavy usage. The water content of polymer hydro gel no.2, no.3 and no.4 of this study is 80% or more and became a factor that can be produced with a lower cost compared to other formulations.

Oil forms a protective layer on the skin which is commonly used in basic cosmetics and body moisturizer[14,15]. The results of this study, it was known that higher the oil content, the production cost was rapidly increasing. since the necessary amount will be at minimum, it can contribute to the cost savings.

The nutrition lotion called emulsion is the most effective product for supplying moisture to the skin and creates smooth and elastic skin by restoring the balance and supplying oil and water[16]. It can be used lightly and it is good to be used as the formulation for ultrasonic transmission media.

The cosmetic production performance in 2013 was increased by 12% compared to the previous year, and the trade index for cosmetics was increased by 3 times compared to the previous year, and especially, the growth of functional cosmetics which are expensive was more largely expanded than the basic cosmetics[17].

The limitations of this study is that the ultrasonic transmission media was produced using a arbitrary component ratio for each formula, thus a study combined with expertise on ideal formulation for acoustic properties required by the ultrasonic transmission media is needed.

A variety of studies on sophistication and diversification of ultrasonic transmission media that meets the modern wellbeing trend is required. It is considered that this study can lay the foundation for future studies.

4. Conclusions

This study will examine the suitable types of As a formulation research of transmission media having different components such as polymer hydro gels, emulsions and oil gels, has analyzed the rheological characteristics and economic costs produced by each formulation.

In the rheological experiment of each media, low viscosity emulsion and oil gel was the best compared to the hydrogel with the cheapest manufacturing cost.

The formulation of the product has a close relationship with the function and target. Although low viscosity emulsion required twice more manufacturing cost than the hydrogel, during the inspection, since the skin moisture contents was higher than the hydrogel, if the ingredients are properly mixed, it is expected to be used as a new ultrasound propagation media.

A variety of studies on sophistication and diversification of ultrasonic transmission media that meets the modern wellbeing trend is required.

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이 혜 남(Lee, Hye Nam)

- 2005년 5월 : ARDMS 취득
- 2011년 8월 : 한서대학교 방사선과 (방사선학석사)
- 2014년 2월 : 한서대학교 보건의료학과(보건학박사)
- 2006년 2월 ~ 현재 : 원광보건대학교 방사선과 교수
- 관심분야 : 방사선학, 보건의료학
- E-Mail : hnlee@wu.ac.kr

박 미 순(Park, Mi Soon)

- 2007년 8월 : 아주대학교 화학생명공학과(공학석사)
- 2015년 2월 : 한서대학교 보건의료학과(보건학박사)
- 2012년 11월 ~ 현재 : 한국임상의학연구소 병리과
- 관심분야 : 진단세포학, 조직학, 병리
- E-Mail : kimpark42000@naver.com

박 연 화(Park, Yeon Hwa)

- 2009년 8월 : 건양대학교 보건행정학 (보건학석사)
- 2011년 2월 : 대전대학교 한의학과 (한의학석사)
- 2014년 8월 : 충남대학교 보건행정 (보건학박사)
- 2012년 3월 ~ 현재 : 건양대학교 방사선학과 겸임교수
- 관심분야 : 방사선학, 보건행정학
- E-Mail : yh6322@hanmail.net