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Sodium Alginate composite film preparation with Nano clay and enhancing its properties

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Abstract—Use of natural polymers from renewable resources has been increasing in recent years due to their excellent performance over existing petro-polymers which are non-environmental friendly. Films prepared from natural polymers such as polysaccharides, proteins, lipids etc., have wide application over packaging sector. Sodium alginate is the sodium salt of alginic acid, which a polyuronide is made up of a sequence of two hexuronic acids: beta-D mannuronic acid and alpha-L guluronic acid. Films obtained from Sodium Alginate hydrocollidal compounds are bio-degradable and bio-compatible with better gel forming and film forming capabilities. The objective of this follow up is to enhance the physical properties of sodium alginate film, prepared with various compositions of $CaCl_2$ and Nanoclay compounds using casting method.

Key words: Calcium chloride, K 10 Nano clay, "Sodium Alginate" chemical formula=$NaC_6H_7O_6$

I. INTRODUCTION

Alginate naturally occurs in seaweed in the form of calcium, magnesium and sodium salts. Alginates are polysaccharides with building blocks comprised of two urinate sugars, the salts of mannuronic and gluronic acid. During extraction of alginates, the uronic acids are converted into the salts forms mannuronate and guluronate through neutralization process. The proportion and distribution of these blocks will decide the property of alginate and the composition varies according to seaweed species and structure.

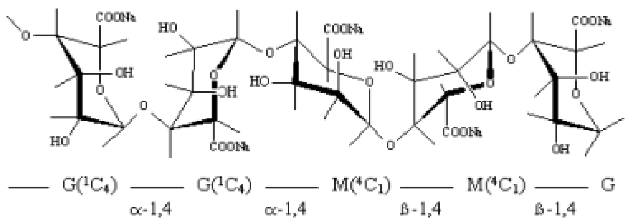


Fig. 1: Structure of Alginate

Sodium alginate has two primary functions namely it thickens a solution to increase viscosity and it binds tightly to various compounds such as calcium for gel forming and film forming applications. It also functions as stabilizer and emulsifier.

II. MATERIALS AND METHODS

A. Materials:

Food grade sodium alginate act as main compound for film preparation was purchased from Balaji Chemicals (Chennai) it can be obtained white to yellowish brown filamentous, grainy, granular or powdered forms. K 10 Nano clay was supplied from lab. In order to improve the mechanical properties glycerol was used which acts as a plasticizer. In addition calcium chloride ($CaCl_2$) was used during film preparation.

B. Film preparation:

Five types of films were prepared from sodium alginate with various compositions of compounds. The films are named as:

- Sodium alginate film
- Sodium alginate enhanced dip film
- Sodium alginate enhanced film
- Sodium alginate and nanoclay film
- Sodium alginate and nanoclay enhanced film

Step. 1 :

Initial step in film preparation common to all the types was film solution preparation. In this process two types of solutions are prepared, namely:

- *Sodium alginate solution:* In order to prepare solution 4 g of sodium alginate powder was added in a beaker containing 200 ml of distilled water along with 2 ml of glycerol and stirred at ---- rpm for 30 minutes with the help of magnetic stirrer for complete dispersion of sodium alginate in water and to increase viscosity. In case of any impurities or agglomerates the solution was filtered.
- *$CaCl_2$ solution:* 1.5 g of Calcium chloride was allowed to disperse in 100 ml of distilled water, the resultant solution obtained was known as $CaCl_2$ solution.

Step. 2 :

- *Sodium alginate film:* to Sodium alginate solution, mixed thoroughly and taken for casting process.
- *Sodium alginate enhanced dip film:* sodium alginate film was dipped in Calcium chloride solution for 30 seconds and allowed for open air drying.
- *Sodium alginate enhanced film:* 1.5 g of Calcium chloride was directly added to sodium alginate solution to obtain film forming solution.
- *Sodium alginate and nanoclay film:* 4 g of nanoclay was mixed in magnetic stirrer with sodium alginate solution to get film forming solution.

Sodium alginate and nanoclay enhanced film 4 g of nanoclay and 1.5 g of calcium chloride was mixed in magnetic stirrer with sodium alginate solution to get film forming solution.

Step. 3 :

Films were made from film forming solutions by casting technique.

In this process, 80 ml of film forming solution is poured over a wax coated petridish or forming dish of 10 cm diameter and allowed to dry for 48 hours in room temperature. Excess water was permitted to evaporate and finally the resultant film can be peeled off from the forming dish.

C. Film Thickness

Film thickness was measured with micrometer. Thickness value is identified with three samples at five distinct points. The average value was set as the final thickness film in terms of millimeter.

D. Testing

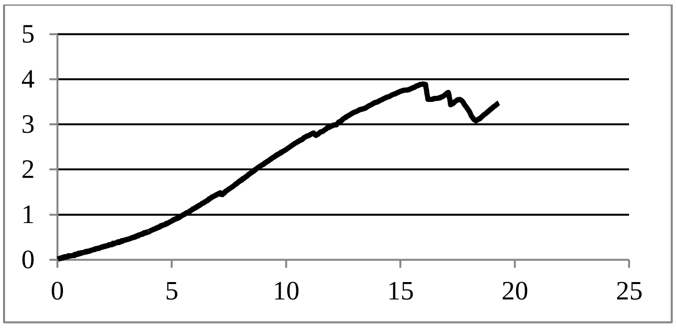
1) Tensile strength and percentage elongation at break:

The tensile strength of a film expressed as the greatest longitudinal stress or tensile force it can bear without tearing apart. Tensile strength can be used as a potential indicator of resistance to breaking during various applications.

Tensile strength and percentage elongation at break for films samples were measured with the help of Universal Testing Machine. Films were made in to necessary dimensions. Tensile force was applied and the samples were allowed to elongate. Cross head extension was varied constantly with the range of 0.04 N with respect to tensile force applied in load cells in terms of Newton. Various parameters such as yield force, percentage elongation at yield, tensile force, and force at break can be determined.

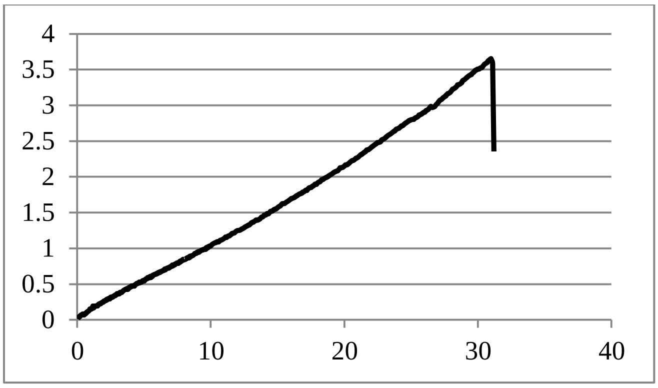
Film	Thickness (mm)	Width (mm)	Yield force (N)	Elongation at yield (%)	Tensile (MPa)	Max Force (N)	Elongation at Max (%)	Elongation %	Force at Break (N)
Sodium alginate film	0.1900	25	1.484	14.24	0.819	3.892	31.92	38.60	3.476
Sodium alginate enhanced dip film	0.1000	20	3.656	124.0	1.828	3.656	124.0	124.8	2.356
Sodium alginate enhanced film	0.5000	25	2.368	43.84	0.2192	2.740	55.6	58.4	2.544
Sodium alginate and nanoclay film	0.3000	20	3.108	36.48	0.518	3.108	36.48	38.80	2.400
Sodium alginate and nanoclay enhanced film	0.2000	25	0.070	1.594	0.1366	0.683	27.63	28.38	0.240

Table. 1: Comparison of Film thickness for Elongation and Tensile Break



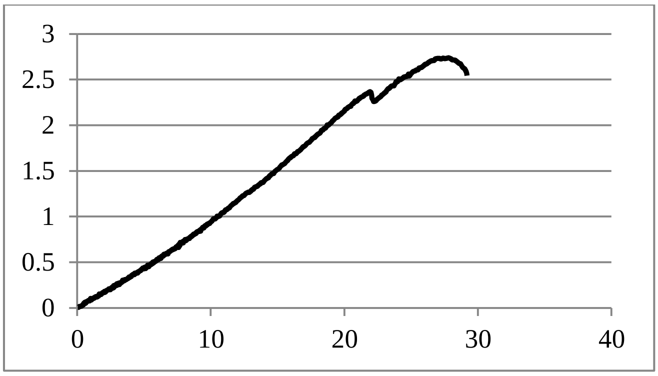
(Note: The following graphs represent change in elongation (mm) at Y-axis due to applied force (N) - X-axis.)

Fig. 2: Sodium alginate film



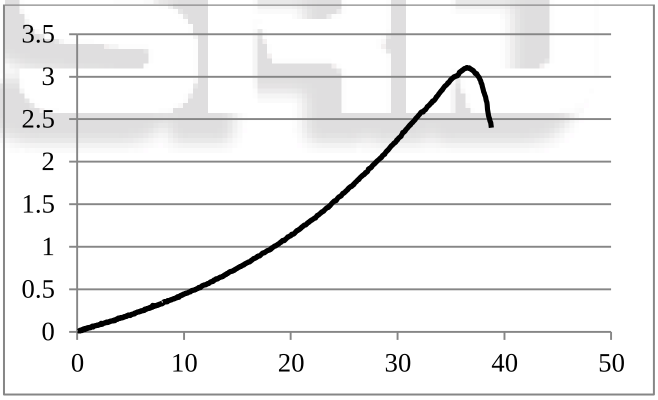
(Note: The following graphs represent change in elongation (mm) at Y-axis due to applied force (N) - X-axis.)

Fig. 3: Sodium alginate enhanced dip film



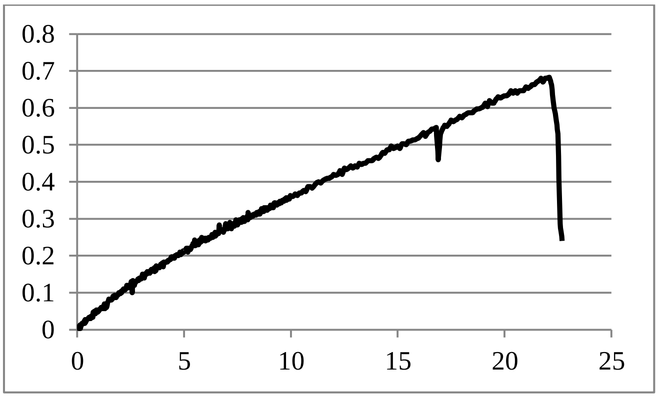
(Note: The following graphs represent change in elongation (mm) at Y-axis due to applied force (N) - X-axis.)

Fig. 4: Sodium alginate enhanced film



(Note: The following graphs represent change in elongation (mm) at Y-axis due to applied force (N) - X-axis.)

Fig. 5: Sodium alginate and nanoclay film



(Note: The following graphs represent change in elongation (mm) at Y-axis due to applied force (N) - X-axis.)

Fig. 6: Sodium alginate and nanoclay enhanced film

2) Scanning electron microscopy (SEM)

The microstructure of sodium alginate and nanoclay composite film was tested with scanning electron microscopy. Dried samples (5 to 3 mm) were mounted on specimen stubs to identify surface structure, binding nature and particle size.

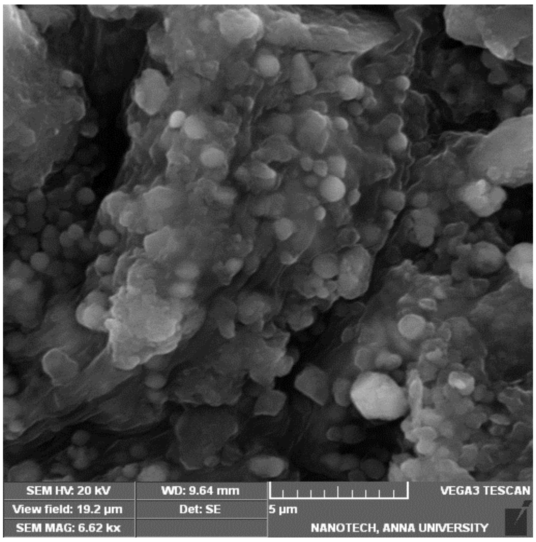


Fig. 7(a)

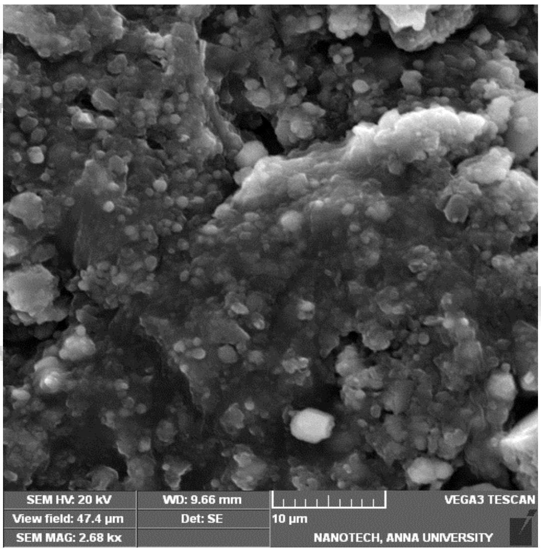


Fig. 7(b)

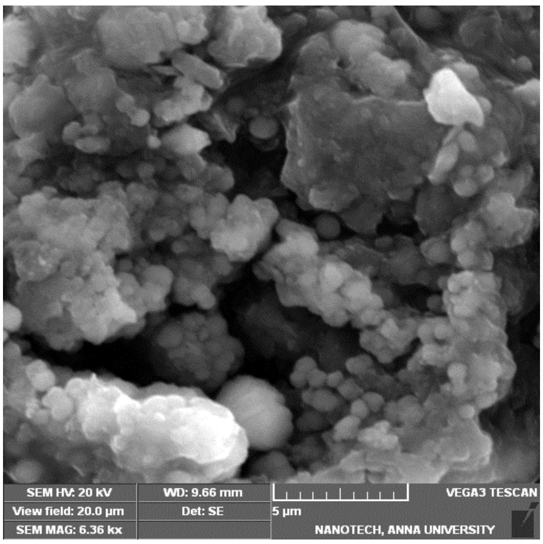


Fig. 7(c)

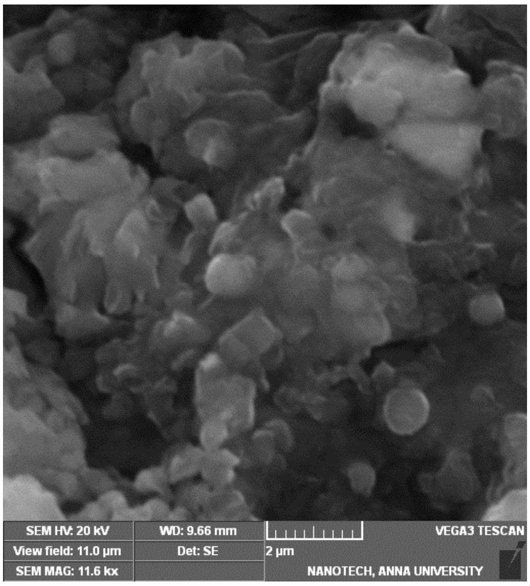


Fig. 7(d)

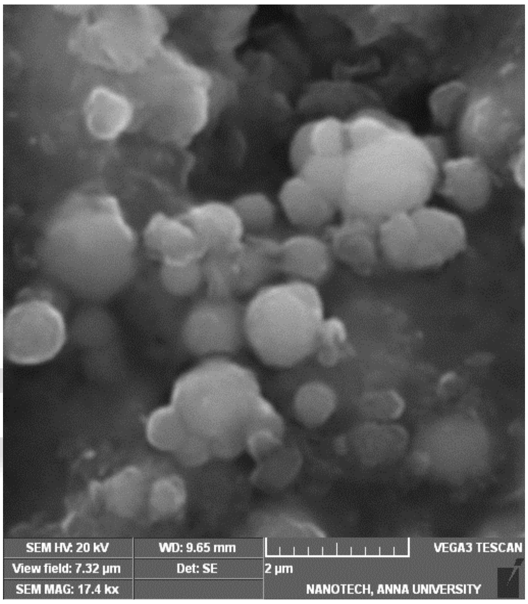


Fig. 7(e)

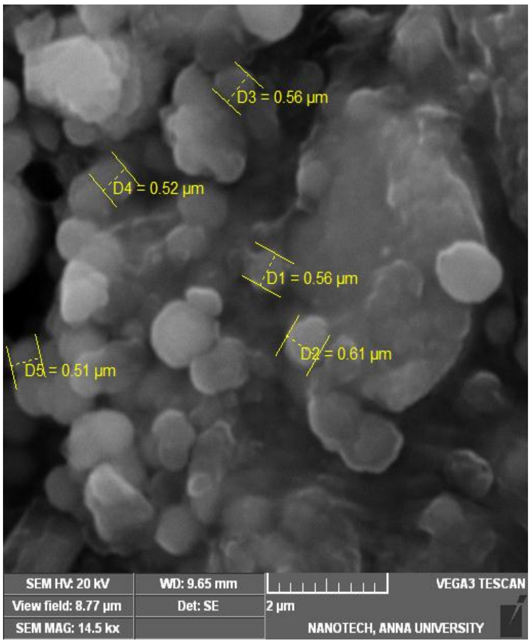


Fig. 7(f)

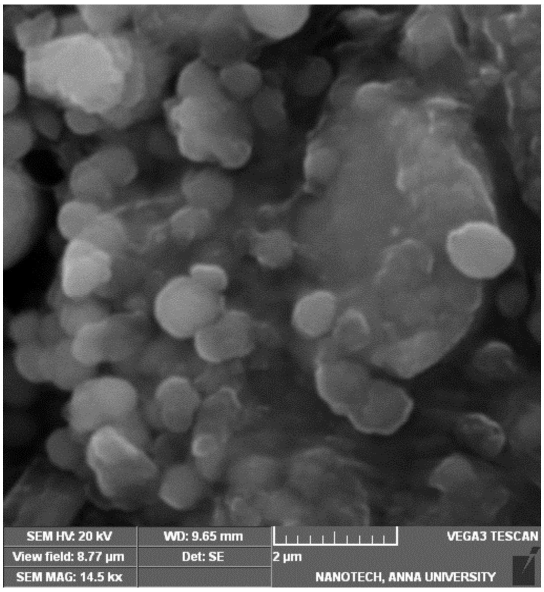
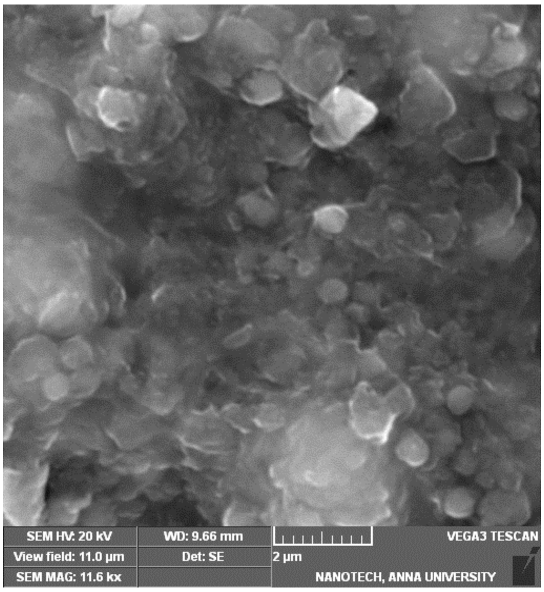


Fig. 7(g)



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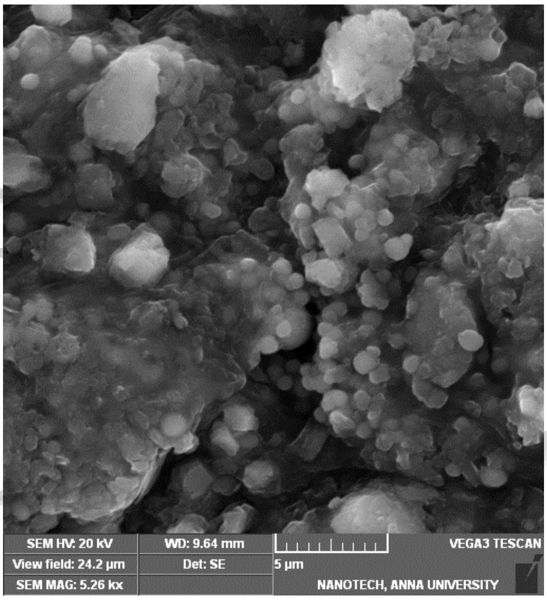

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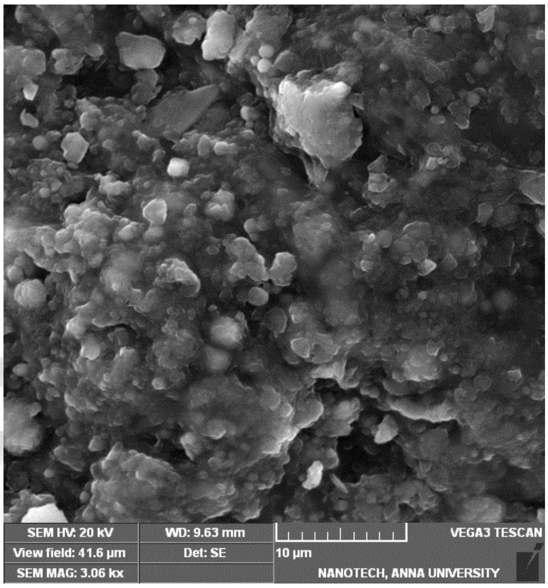

Fig. 7(k)

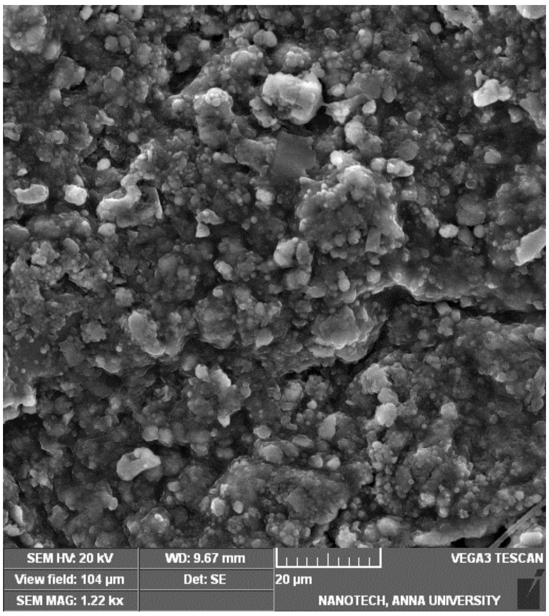

Fig. 7(i)

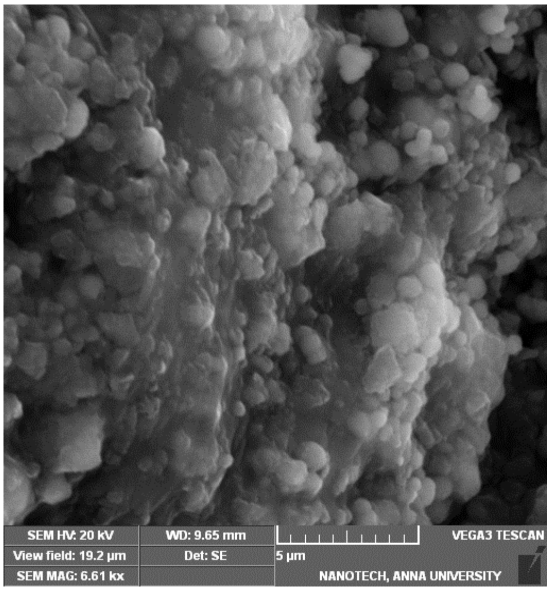

Fig. 7(l)

Fig. 7 (a) – (l): Scanning electron microscopy of specimen

III. RESULTS AND DISCUSSIONS

A. Tensile strength and percentage elongation at break

When thickness of sodium alginate nanoclay film was increased by 63% of sodium alginate film, percentage elongation varies nearly 40%. Addition of Calcium chloride increases mechanical property of sodium alginate films.

B. Scanning electron microscopy (SEM)

SEM images indicate that the high degree of dispersion of clay in the polymeric matrix of sodium alginate.

IV. CONCLUSION

Enhancing sodium alginate films with calcium chloride increases water resistance capability. This special property concludes that sodium alginate enhanced films can be used as an application for water resistance packaging. Nanoclay act as excellent filler for sodium alginate matrix, it leads to increase in barrier property for the film.

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