Effects of Sawdust and Rice husk Additives on Physical Properties of Ceramic Filter

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Abstract

Two processes were employed for forming, specifically, slip casting and semi-dry press were used to manufacture ceramic filters from local raw materials, red clay and combustible materials (sawdust and rice husk). Different proportions of additives were used as pores forming agents to create porosity in ceramic filter. Dried filters were fired at temperature to 1000°C.

It was found that the forming technique and additives have great effect on the physical properties of the produced ceramic filters. The slip casting technique was more suitable procedure for producing a porous ceramic filter. As well as, porosity increased as percentage of the combustible materials increased.

Keywords: Ceramic Filter, Combustible Material, Porosity.

الخلاصة

استخدمت طريقتان لتشكيل المرشحات السيراميكية، وبالتحديد، الصب الانزلاقي والكبس شبه الجاف لتصنيع المرشحات السيراميكية من المواد الخام المحلية كالطين الأحمر والمواد القابلة للاحتراق (نشارة الخشب وقشر الأرز). تم استخدام نسب وزنية مختلفة من المواد المضافة كعامل تشكيل المسام لخلق المسامات في المرشح السيراميكي. حرقت المرشحات المشكلة عند درجة الحرارة إلى 1000 درجة مئوية.

وقد وجد أن تقنيات التشكيل والإضافات لها تأثير كبير على خصائص المرشحات السيراميكية الناتجة. طريقة الصب الانزلاقي هي الطريقة أكثر ملاءمة لإنتاج المرشح السيراميكي المسامي. وكذلك تزداد المسامية مع زيادة نسبة المواد المضافة.

الكلمات مفتاحية : المرشح السيراميكي، المواد القابلة للاحتراق، المسامية.

1. Introduction

A filter is an instrument or device, that removes something from whatever passes through it. So, ceramic water filtration can be defined as the method that use of a porous ceramic medium to filtrate water from contaminants or microbes. From the ancient times to the present, water filters have evolved out of necessity, first to improve bad tastes and further to remove contaminants that can cause diseases, then to remove materials that affect appearance (Erhuanga *et.al.*, 2014).

Filtration is an old, known and very effective process for eliminating pathogens from water. Ceramic filters are especially desirable because of their ease of fabrication and use, low cost, and their ability to filtrate the water from bacteria (Abiriga *et.al.*, 2014)

The performance of clay filters can be significantly improved by the use of burnout materials which increase flow rate by creating a network of pores and the use of bactericidal compounds for destruction of pathogens. Low cost clay filters for drinking water purification in developing countries is diversified, different from the production process, overall design, assurance and control of quality, clay and other materials, firing temperatures and burnout material, and sometimes chemical (e.g., colloidal silver) materials, and other properties (Nnaji *et.al.*, 2016).

The advantages of locally produced ceramic filters are that they are portable, light in weight, affordable and require low-maintenance (Isikwue *et.al.*, 2011 and Unisef, 2007).

The requirements for water filtration different from region to region depended on impurity properties such as, chemicals, metals organic matter and microbes. Some of the point-of-use processes and instruments for eliminating the above mentioned impurities are solar disinfection, chlorination, bio-sand filters and ceramic filters (Plappally *et.al.*, 2009).

Clean water is one of the most important public health measures in providing major controls against infectious diseases apart from safe food and up-to-date medical care (Isikwue *et.al.*, 2011). Drinking water conditions have great effects on people's everyday life, where access to safe drinking water is very limited especially in developing countries. Unsafe drinking water causes diarrhea and other water borne diseases. According to the World Health Organization (WHO), in developing countries, children's resistance to infections is low, and thus, cause death ninety percent of children under five years old (Agbo *et.al.*, 2015 ; Clasen *et.al.*, 2005).

The present paper aims to Manufacture filters from clay and additives of sawdust and rice husk to show the effect of additive type and weight percent of the physical properties and knowing the fabrication method effect upon the performance of ceramic filter.

2. Experimental

The experiments in this study were achieved in the laboratories Ceramic and Building Materials Department, Material college/ Babylon University.

(A) Preparation of clay powder

The clay samples in this study were collected from the deposit in the Mahaweel area of the Babylon province. These samples are washed, dried and ground, after grinding the powder was evaluated by particle size analyzer (Type Better 2000) which is available in the ceramic and building materials department, Engneering Materials College, University of Babylon. The fine size of clay (<75 µm).

(B) Preparation of sawdust and rice husk powders

Rice husk was used as combustible material. It was obtained from the workshop in Hilla city. It is washed, dried and finally crushed in an electric mill, and then ground in fine size (< 85 and 80)µm of sawdust and rice husk respectively.

(C) Slip-Casting Method.

Slip-casting was used to prepare samples for batches at different ratios as shown in Table (1). The slip is poured into a plaster of Paris mold to produce ceramic filter in cylindrical shape. The samples were left until the cast dries and then fired.

(D) Semi-dry Pressing Method.

Uniaxial semi-dry pressing technique was employed to form ceramic filter samples for batches at different proportions as shown in Table (1). All samples were pressed into cylindrical form by using steel mold, the samples had a diameter of 30 mm and 3 mm in height (thickness).

3. Determination of physical Properties

3.1 Bulk Density and Porosity

The bulk density and apparent porosity were based upon ASTM-C373 standard, 2006. After the dry and saturated weights of the sample were determined.

Bulk density= $[W_1/(W_2-W_3)] * \rho w$

Apparent porosity= $[(W_2-W_1) /(W_2-W_3)] *100\%$

Where:

$W1$– dry weight; $W2$- saturated weight; $W3$- immersion weight and ρW- density of wate

3.2 Permeability

It is a physical property of the material in which ability of porous media to transmit fluid through it [Bear, 1972]. In 1856, Henry Philibert Gaspard Darcy which is the first developed the equation to depict fluid flow through a porous medium as follow:

K =Q. L/A.h

Where:

Q- is total discharge; L- length of the sample; A- cross section area; h- constant head at the ceramic filter and K- constant of proportionality which commonly known as a hydraulic conductivity.

3.3 Turbidity

It is the haziness of a fluid caused by the invisible suspended particle like organic, inorganic materials and plankton. The measurement of turbidity is the way by which the water quality is known. In the field of drinking water, high level of turbidity may be caused a risk developed in human body, because viruses or bacteria may attached upon those suspended in water. There are many methods by which the turbidity can be measured. The scattered light incident upon the suspended particles in the water column is considered the common measure of turbidity. The instrument which uses this method for measuring turbidity is called a nephelometer. Hence, the unit of turbidity is the calibrated nephelometer which is called Nephelometer Turbidity Unit (NTU) (Dezuane, 1997).

4 Preparation of ceramic filter

Powder clay and additives (sawdust and rice husk) were prepared through many steps. These powders were mixed in the ratios of 98:2, 96:4, 94:6, 92:8, 90:10, 80:20 and 70:30 by volume of clay to sawdust or rice husk. Water was added to the mixture up to 20% by volume to improve the workability of the mixture.

Group A ceramic filters were fabricated by forming in the plaster mold using slip casting.

Group B ceramic filters were manufactured by compacting 5g of each of the mixture to a pressure of 49 kN using a semi-dry pressing.

The filter samples were formed into cyljndercal discs of diameter 30mm and thickness 3mm. The green bodies were dried at 105 °C and fired to 1000 °C.

5. Results and discussion

The results of physical properties tests are presented in Tables 2 (a, b).

a. Bulk Density and Porosity

Fig.1 shows the effect of additives (sawdust, rice husk) upon the property of apparent porosity of the ceramic filter. The porosity of the filter increased linearly with an increase in the amount of sawdust or rice husk additives (Musa, 2010). On the other hand, the forming process was produced a contrast in porosity, where the slip casting technique had given a preference in porosity value (86% and 66%) with the sawdust and rice husk additives rather than the pressing process in which the porosity value of the same additive records approximately (76% 53%). This disparity in porosity values between the two techniques gives an indication that, the compacting forces in the pressing forming were caused converge of the particles more than done in the slip casting process. So, the slip casting technique is more suitable procedure for producing a porous ceramic filter.

Fig.2 depicts the relationship between the increments of additives with the apparent density of the ceramic filter. It is due to the fact that the density of the ceramic filter is inversely related to the porosity. So, as the additive ratio is further increased, the density values of the samples are rapidly decreased. It has been observed that the behavior of the density of the samples follows the same trend as explained in the porosity article. The samples which are fabricated by the slip casting method show less density than those forming by the pressing technique. [S. C. Agbo, et.al, 2015]

b. Permeability

Fig.3 explains the discharge of water per a unit of time for the prepared ceramic filter with different additive ratio. The permeability of the filters increased with increasing porosity. It can be seen that permeability of water differs depending on the kind of addition, implying that the permeability of water is affected by porosity by the filters. It may be noted that the fabrication process of the ceramic filter does not obviously effect on the permeability values. Because, there are other factors pronounced impact upon the permeability such as pore size distribution and pore volume of the ceramic filter. (Musa, 2010)

c. Turbidity

Tables 3 (a, b) show turbidity test results for samples made by slip casting and pressing techniques. The samples which are manufactured by slip-casting have higher levels of turbidity rather than the pressing process indicating that, the pores of large diameter making it easy cross the particles through the filter samples. But the pressing technique gives turbidity values less due to compacting forces which led to convergence grains (Isikwue *et.al.*, 2011).

Fig. 3 shows scanning electron micrographs of the filter samples. It may be observed that, the resulting pores after burning each of sawdust and rice husk additives have an irregular shape, and appear larger in the slip casting process rather than the pressing process due to compact forces in the pressing process.

6. Conclusions

1. Manufacturing ceramic filter from local material clay and additives (sawdust and rice husk) by two simple techniques slip casting and semi-dry pressing that give samples with high porosity by slip casting process than the pressing process.
2. In slip-casting, ceramics porosity is higher than in semi-dry press,The disparity in porosity values between the two techniques gives an indication that, the compacting forces in the pressing forming were caused converge of the particles more than done in the slip casting process.
3. The pores of sawdust are larger therefore giving high porosity and low density than the pores of rice husk.

Table 1: Composition of red clay and additives mixture

Starting Materials / Batch No.	Red clay %	Additives	
		Sawdust	Rice husk
1 , 2	98	2	2
3 , 4	96	4	4
5 , 6	94	6	6
7, 8	92	8	8
9, 10	90	10	10
11 , 12	80	20	20
13 , 14	70	30	30

Table 2a: Result of physical analysis for a water filter disc with sawdust by slip casting

Addition Ratio / Physical Properties	2%	4%	6%	8%	10%	20%	30%
Porosity %	47.5	51.6	55	55	58.4	68.4	84.6
Density g/cm^3	1.38	1.32	1.28	1.13	1.09	0.94	0.69
Permeability cm/min	3*10^-7	4*10^-7	1*10^-6	2*10^-6	2*10^-6	1*10^-5	6*10^-5

Table 2a: Result of physical analysis for a water filter disc with rice husk by slip casting

Addition Ratio / Physical Properties	2%	4%	6%	8%	10%	20%	30%
Porosity %	48.5	44.8	47.1	50	54.6	65	66.6
Density g/cm^3	1.65	1.63	1.60	1.43	1.26	1.13	1.09
Permeability cm/min	2*10^-7	2*10^-7	3*10^-7	4*10^-7	2*10^-6	3*10^-6	5*10^-6

Table2b: Result of physical analysis for water filter disc with sawdust by semi-dry pressing

Addition Ratio / Physical Properties	2%	4%	6%	8%	10%	20%	30%
Porosity %	42.9	47.2	51.4	53.2	59.4	65	70
Density g/cm^3	1.62	1.57	1.38	1.37	1.28	0.95	0.81
Permeability cm/min	4*10^-7	5*10^-7	1*10^-6	1*10^-6	2*10^-6	2*10^-5	1*10^-4

Table 2b: Result of physical analysis for a water filter disc with rice husk by semi-dry pressing

Addition Ratio / Physical Properties	2%	4%	6%	8%	10%	20%	30%
Porosity %	37.7	40.4	43.1	45.7	47.9	50.1	53.8
Density g/cm^3	1.72	1.71	1.67	1.50	1.44	1.37	1.10
Permeability cm/min	5*10^-8	6*10^-8	6*10^-8	7*10^-8	8*10^-7	1*10^-6	5*10^-6

Table 3a: Result of turbidity test for water filter discs with sawdust

Addition Ratio / Methods	2%	4%	6%	8%	10%	20%	30%
Slip casting	1.42	2.99	3.57	4.36	5.1	6.30	3.11
Semi-dry pressing	1.82	1.18	2.13	1.98	3.51	2.73	2.14

Table 3b Result of turbidity test for water filter discs with rice husk

Addition Ratio / Methods	2%	4%	6%	8%	10%	20%	30%
Slip casting	4.17	5.21	2.66	5.52	5.15	6.79	5.33
Semi-dry pressing	2.57	3.61	2.4	3.11	3.62	2.21	3.59

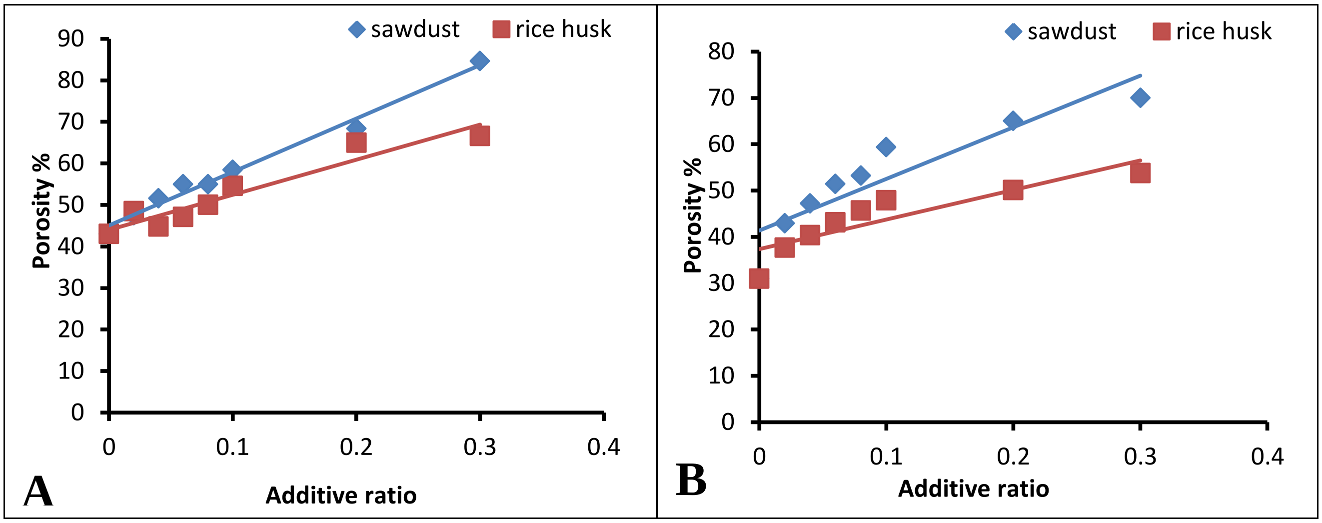

Figure 1: Porosity change with additives (sawdust and rice husk) by (A) Slip casting and (B) Pressing

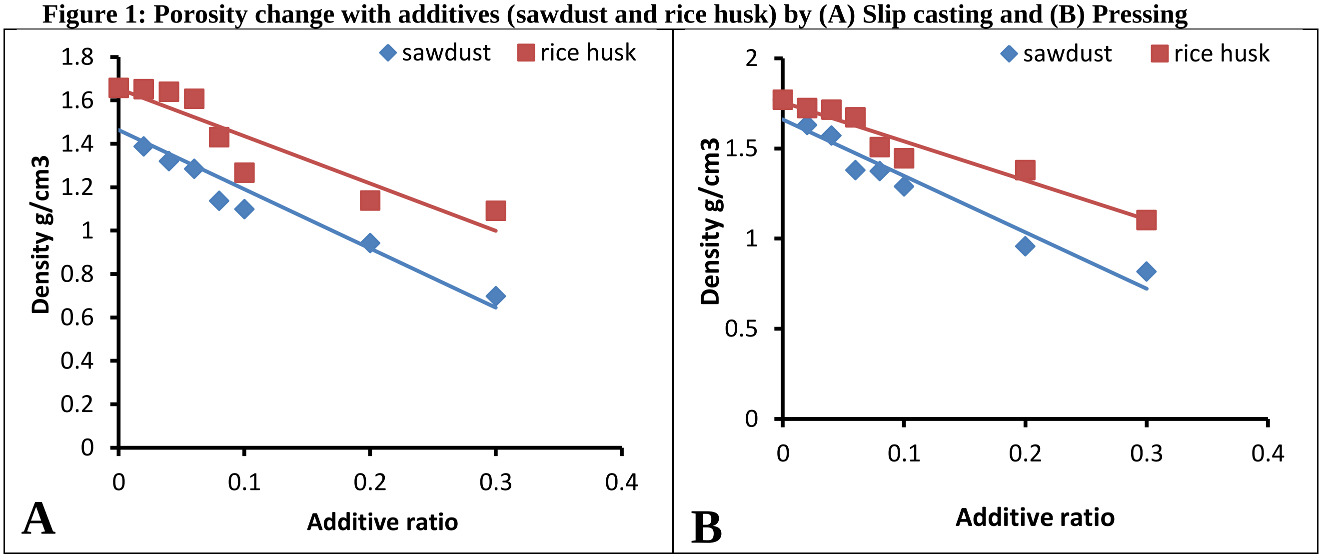

Figure 2: Density change with additives (sawdust and rice husk) by (A) Slip casting and (B) Pressing

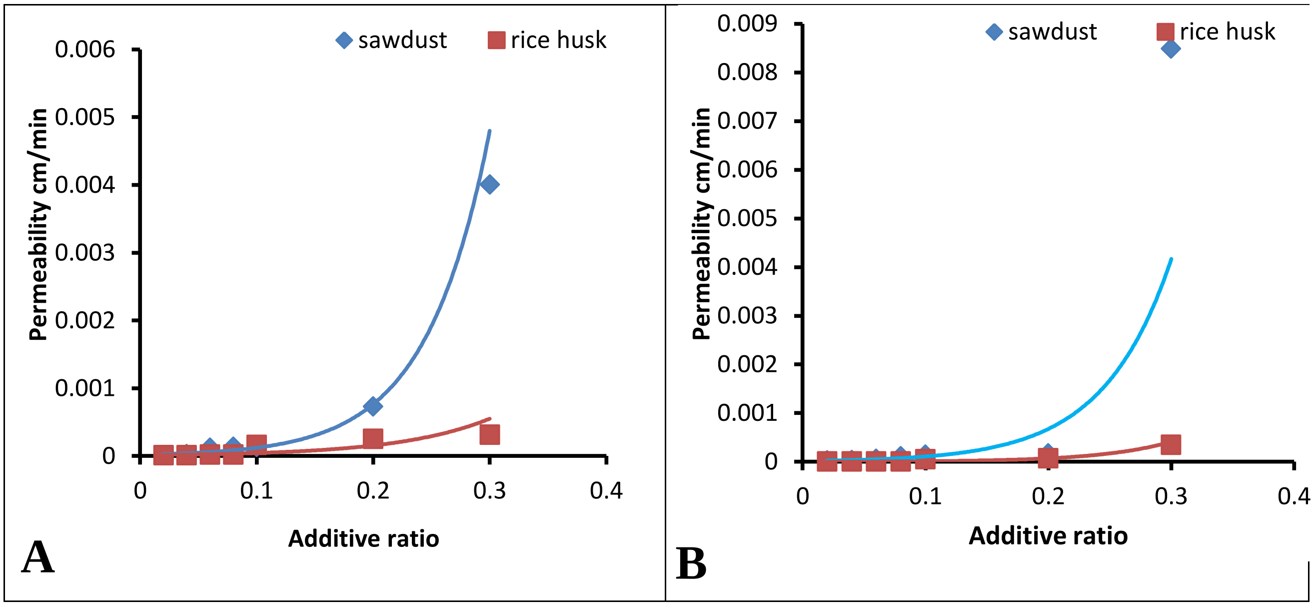

Figure 3: Permeability change with additives (sawdust and rice husk) by (A) Slip casting and (B) Pressing

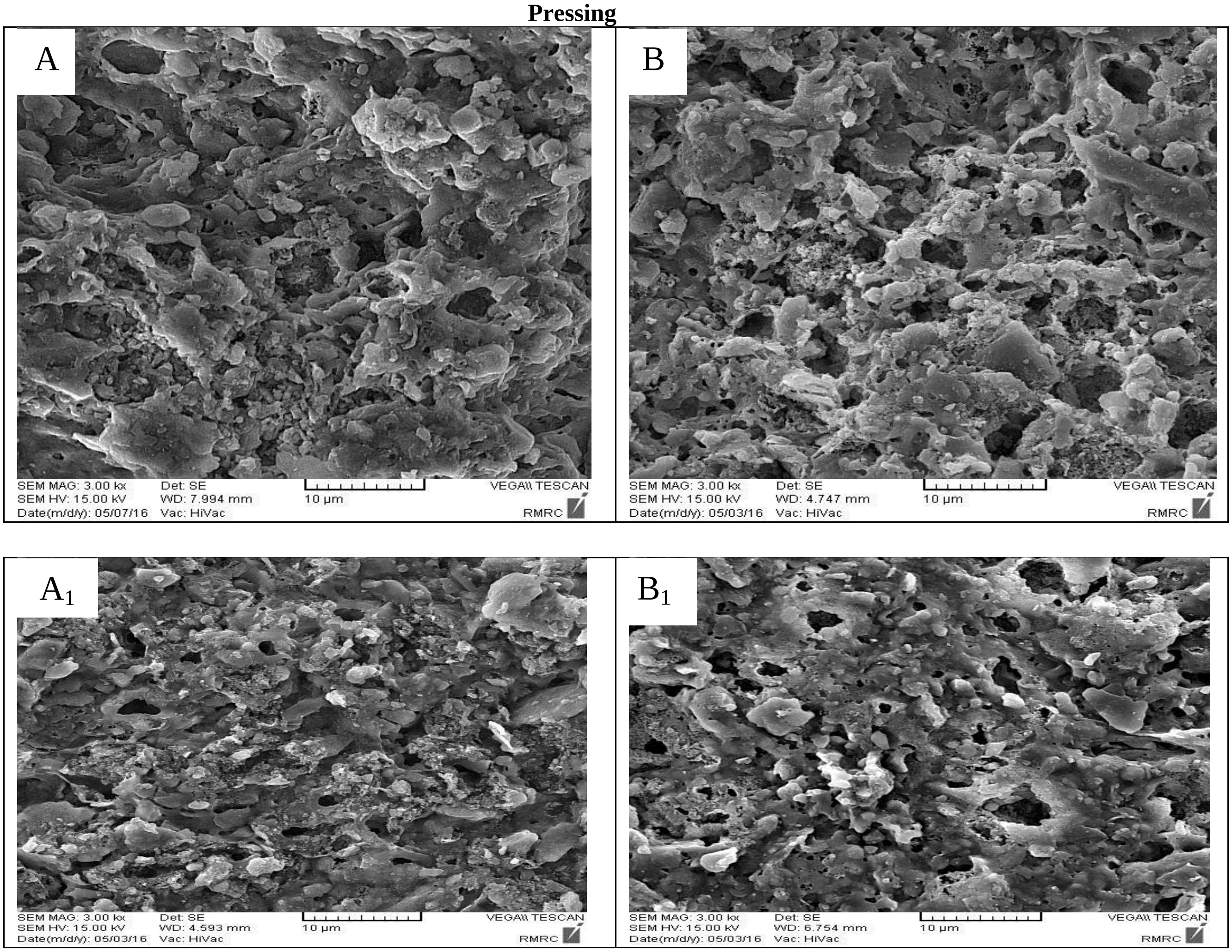

Fig. 4: Scanning electron micrograph of filter samples (A, B) 10% of sawdust and rice husk in slip casting and (A_1, B_1) 10% of sawdust and rice husk in pressing.

B_1

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